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TOWARDS CLIMATE-SMART SUSTAINABLE MANAGEMENT OF AGRICULTURAL SOILS IN FLANDERS

Part I: EJP SOIL survey on current policy ambitions and future soil aspirational goals

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Auteurs

Greet Ruysschaert

Miro Jacob

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Abstract

The study presented in this report provided input for EJP SOIL task 2.1 (Deliverable 2.5) on current policy ambitions and realisations for agricultural soils and soil management in Flanders and soil aspirational goals by 2050. It builds on a desk study of the current policy ambitions and realisations in Flanders followed by an in-depth stakeholder survey including ten key stakeholder organisations (30 experts). The desk study includes an overview of targets, indicators, monitoring tools, instruments and management practices mentioned in policy packages that impact agricultural soils and soil management. Most policies that affect agricultural soils and soil management are regional matter and many are derived from EU policies. The largest focus in soil policy is on soil organic carbon, soil erosion, soil contamination, and nutrient retention/use efficiency. Currently, there are only few quantified targets that explicitly address agricultural soil challenges in Flanders and there is no systematic statistically-sound soil monitoring on-going. Policy documents mention a.o. the need to stimulate soil scans and smart measurement systems to facilitate data driven farm management and the use of decision support tools. Of all management practices mentioned in policy documents, 60% belong to the categories crop choice/rotations and organic matter/nutrient management and are indicated to be important for multiple soil challenges. Despite the fact that soils are mentioned and targeted in many policies, an overarching soil policy framework is missing in Flanders. The potential gaps between the realisation of current policy ambitions and aspirational goals towards 2050 were scored by the stakeholders. Overall, gaps between current realisations and what would be futureproof targets are large for all soil challenges and most progress has already been made for soil erosion and soil contamination. To bridge the gap, practices belonging to organic matter and nutrient management are most mentioned by stakeholders (25%) and are regarded to be mainly important for avoiding acidification, avoiding N_2O/CH_4 emissions and enhancing nutrient use/use efficiency. Crops and crop rotations (21%) are regarded especially important for maintaining/increasing SOC and to avoid soil erosion. Cover crops/catch crops and more grassland are both by policy and stakeholders regarded as beneficial for multiple soil challenges. In comparison with management practices mentioned in policy, stakeholders paid more attention to the potential of practices in the categories tillage/traffic, agricultural systems and water management and less in the category buffer strips/landscape elements. Stakeholders also stressed the need for a system view and the importance to combine measures. A prioritization by the stakeholders indicated that maintaining/increasing soil organic carbon (SOC) is by far the most important soil challenge for the upcoming decades, followed by enhancing water storage capacity, enhancing soil biodiversity and enhancing soil nutrient retention/use efficiency. From the policy and stakeholder analysis, an overview of knowledge needs and instruments towards climate-smart sustainable soil management in Flanders is derived and included in the report.

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1. Introduction

The main objective of the European Joint Programme **EJP SOIL** (2020-2024; www.ejpsoil.org) is to enhance the contribution of agricultural soils to key societal challenges such as climate change adaptation and mitigation, sustainable agricultural production, ecosystem services provision, prevention and restoration of land and soil degradation and biodiversity maintenance.
The EJP SOIL consortium unites a unique group of 26 European research institutes and universities in 24 countries. National research efforts are pooled in order to make better use of Europe's research and development resources. EJP SOIL activities closely interact with stakeholders of different categories, including policy stakeholders, farmers and farmer organisations, research communities, NGOs and agro-industry.

One of the objectives of EJP SOIL is to develop and deploy a **roadmap for climate-smart sustainable agricultural soil management research**. From this roadmap activities for the work packages are defined and research topics are selected for internal and external project calls. In order to develop this roadmap, in the first year of EJP SOIL, a number of inventories and stock takes activities have been conducted, i.e.:

- Task 2.1: Agricultural soil service aspirations at regional, national and European levels
- Task 2.2: Knowledge availability and use
    - Subtask 2.2.1: Knowledge availability
    - Subtask 2.2.2: Knowledge use
- Task 2.3: Identification of barriers and opportunities by scenario development
- Task 2.4: Reviews of key agricultural soil related issues for all members states in EJP SOIL, with 5 stock takes
    - Synthesis on the impacts of sustainable soil management practices;
    - Stocktaking on soil quality indicators and associated decision support tools, including ICT tools;
    - Stocktaking on estimates achievable soil carbon sequestration on agricultural land in the EU;
    - Inventory of the use of models for accounting and policy support (soil quality and soil carbon) in partner countries;
    - Stock take study and recommendations for harmonizing methodologies for fertilization guidelines across regions.

All partners were required to collect the necessary information for these inventories and stock takes for their countries or regions, involving a broad range of stakeholders and based on a methodology outlined by the respective task and stock take leaders. After, the information from the different countries was compiled in overall reports per task or stock take. These reports are publically available on (www.ejpsoil.org).

In this report (ILVO mededeling 271), the results for Flanders for task 2.1 are compiled. The results of the other tasks can be found in ILVO mededeling 272[1].

[1] Ruysschaert, G., De Boever, M., Jacob, M., Maenhout, P., D'Hose, T., 2021. Towards climate-smart sustainable management of agricultural soils in Flanders. Part II: EJP SOIL survey on current research knowledge and stakeholder views on knowledge needs, barriers and opportunities for the knowledge system. ILVO mededeling 272.

The **aim of this report** is to **analyse current policy ambitions and realisations on agricultural soils and soil management in Flanders (Belgium)** and to summarize **stakeholder responses** on soil aspirational goals by 2050.

The results of this report are integrated in the overall task 2.1 report summarizing the results of all participating EJP SOIL member states and the EU level[2].

[2] Jacob, M., Maenhout, P., Verzandvoort, S., Ruysschaert, G., 2021. Report on identified regional, national and European aspirations on soil services and soil functions. EJP SOIL Deliverable D2.5. 184p.

2. Approach

In the study, the EJP SOIL glossary was used (Annex I). Policy targets were grouped for the so-called soil challenges and management practices were clustered in land management categories.

This study consisted of two phases. The first phase is a desk study phase in which policy documents and market-based initiatives were analysed to detect current policy ambitions and realisations. In the second phase, the opinion of key stakeholders was asked on how they perceive policy realisations and what aspirational goals for agricultural soils and soil management they would express towards 2050.

2.1 Phase 1: Desk study on current policy ambitions and realisations

Phase 1 consisted of three steps (i) identification of relevant policy documents, (ii) analysis of the policy documents, (iii) validation by key contact persons and finalising the draft task 2.1 member state report based on phase 1.

In **step 1 'identification of relevant policy documents'**, three types of documents were considered that formulate targets for agricultural soils or mention management practices that impact agricultural soils. These documents are on (i) policies that are national or regional transpositions of European legal acts, (ii) policies that are not linked with European policies but are specific for the country or a region, (iii) important market-based initiatives with a clear link with soil, fertiliser or manure management. In Flanders, no market-based initiatives were identified, so they are further not considered anymore in this report.

Regarding transpositions of EU legal acts, it was investigated if and how the following EU legal acts were transposed into national or regional legislation:

- Common Agricultural Policy (2014-2020)
    - Greening measures (A-GM)
    - Cross-compliance – including good agricultural and environmental conditions (+ additional requirements) (A-CC)
    - Rural development – including agri-environmental schemes (A-RD)
- 2030 Climate and Energy Framework –-> national energy and climate plan (NECP)
- 2050 Long-term climate strategy - > national long-term strategies (NLS)
- EU Climate change adaptation strategy -> national adaptation strategies (NAS)
- Nitrates Directive (91/676/EEG, December 12 1991) -> National and regional action programmes (ND)
- Water Framework Directive (2008/98/EC) (WFD)
- Groundwater Directive (GD)
- Floods Directive (FD)
- Areas of Natural or other specific constraint (ANC)
- Habitat Directive (92/43/EEG) (HD)
- (Birds Directive 79/409/EEG (BD))
- Sewage Sludge Directive (86/278/EEG) (SSD)
- Sustainable Use of Pesticides Directives (2009/128/EC) (SUP)

- Environmental Impact Assessment (EIA) Directive (85/337/EEC amended by 97/11/EC and 2003/35/EC)
- Strategic Environmental Assessment (SEA) Directive (2001/42/EC).

For each of the documents found, a key person, mostly at policy departments, was identified that was closely involved with the development of the policy packages or has good knowledge on its content and how it was developed.

In **step 2**, the **gathered documents were analysed** and the following information was extracted:

- Policy targets on soils;
- Indicators used to monitor the targets;
- Current status of the indicators;
- Tools or methods used for monitoring and phase of development;
- Farm management practices that are mentioned in the documents to reach the targets;
- Other policy instruments mentioned in the documents used or to be developed to reach the targets and phase of development.

In **step 3**, the key persons identified in step 1 were asked to validate our analysis of the policy document they are familiar with. They were asked if the analysis was correct and complete.

2.2 Phase 2: Stakeholder views on current realisations and future aspirational goals

In phase 2, key stakeholder have completed a questionnaire that was based on the policy analysis of phase 1. The questionnaire consisted of 4 main steps: (i) policy analysis validation, (ii) assessing policy realisation and defining aspirational goals, (iii) how to achieve aspirational goals and (iv) policy prioritization. The questionnaire that was sent to the stakeholders is added to Annex II.

In **step 1**, the stakeholders were asked to validate the draft policy analysis compiled in phase 1. Based on these comments some amendments were made to the analysis. These finalised tables are shown in chapter 3 'Analysis of current policy ambitions and realisations'. The amendments that were made after the questionnaires were completed by the stakeholders are indicated with '*'. These amendments were thus not taken into account in phase 2 by the stakeholders. The amendments do not include key elements. The stakeholder validation thus confirms that key policies and targets were integrated in the initial policy analysis of phase 1.

In **step 2**, the stakeholders were asked to provide their expert opinion on the current realisation of the policy ambitions and targets set in the policy analysis. This had to be evaluated per soil challenge. To do this, they were asked to indicate how wide the gap is between the current policy target and realisation. To answer this question a likert scale with five categories (very large, large, halfway, small and no gap) was provided. The stakeholders were also asked to write a short argumentation explaining their vote.

In addition, after evaluating the realisation of the current policy targets, the stakeholders were asked to answer whether the current policy targets are futureproof with a horizon to 2050. Again, a likert scale was used to answer the question and an argumentation was asked. The likert scale had four options (futureproof, almost futureproof, far from futureproof, very far from futureproof).

For both questions, the stakeholder votes were compiled by calculating the vote proportion per category of the likert scale. Next to the proportion, the argumentations and the background information provided by the stakeholders was summarized.

In **step 3**, the question how to achieve the aspirational goals set in step 2 was answered by the stakeholders. The stakeholders had to indicate three priority management practices for each soil challenge and indicate potential other instruments. However, despite this guideline, several stakeholders selected more than three management practices per soil challenge. Therefore, all management practices that were selected by a stakeholder got a score equal to one divided by the number of management practices selected for that soil challenge. The sum of these scores was thus always equal to one for each soil challenge. After, per soil challenge, the scores provided by the stakeholders were averaged and expressed as percentage. They also had the change to provide comments and to suggest other instruments to reach aspirational goals.

In **step 4**, the stakeholders were asked to prioritise the soil challenges, by answering the question '*what do you expect that will be the main soil challenges that are most relevant for Flanders in the upcoming decades*'. The stakeholders were asked to attribute a total of 100 points between the various soil challenges. The different stakeholder votes were combined by calculating the average for every soil challenge. The same question was also asked to the stakeholders who completed the other questionnaires that were launched at the same time (see below) and the combined results are shown.

This questionnaire belonged to a **series of three questionnaires** that was sent to key stakeholders in Flanders simultaneously (see also Introduction and ILVO mededeling 272). 115 persons from 34 organisations received a personalized invitation by e-mail to attend a webinar (June 8th 2020) in which the objectives of EJP SOIL in general and the purpose of the questionnaires was explained. The stakeholders were free to choose to what questionnaire(s) they wanted to contribute to given their expertise and interest. After the completion of the questionnaire, the participants were contacted again if anything was unclear.

Ten organisations have completed the questionnaire that is discussed in this report: BoerenBond/Innovatiesteunpunt/Groene Kring, Agrobeheercentrum, PCG, PIBO, Department of Agriculture and Fisheries, Department of Environment (2), OVAM, VLM, ILVO. In most cases, several persons from one organisation have contributed to the organisation's questionnaire. Sometimes they agreed on their answers, but in other cases the persons scored independently. Then, average scores were calculated for that organization/questionnaire. In total 30 persons from those 10 organisations have contributed, see below for more details.

Stakeholder groups	**Number of participating organisations (Number of participants)**
National European soil partnership representatives	*One of the policy stakeholder organisations is also representative of the European soil partnership (Department of Environment)*.
National policy stakeholders (local governance and policy implementing representatives)	Five regional policy stakeholder organisations working on soils, manure legislation, soil contamination, agriculture and climate. In Belgium, this is all regional matter (level of Flanders) (14 participants from the Department of Agriculture and Fisheries, the Department of Environment (2), OVAM, VLM)
Research communities	One research organisation (6 participants from ILVO)
Advisors	Two organisations with advisory services (4 participants from PCG, PIBO)
Farmers' organisations	Two farmers' organisations (6 participants from BoerenBond/Innovatiesteunpunt/Groene Kring and Agrobeheercentrum)
Total sum of participants	**10 organisations (30 participants)**

3. Analysis of policy documents to identify current policy ambitions and realisations on agricultural soils

3.1 Inventory of policy documents

An overview of policy packages that impact agricultural soils and soil management is provided in Table 1.

Table 1: *Overview of policy packages of importance for agricultural soils and soil management.*

Policy ID	Policy Name[a]	Corresponding EU policy	Government level	Responsible policy department
A-CC	Common Agricultural Policy – Cross-compliance (A2014) – Gemeenschappelijk landbouwbeleid randvoorwaarden	Common Agricultural Policy – Cross-compliance 2014-2020	Regional (Flanders)	Policy department of Agriculture and fisheries
A-GM	Common Agricultural Policy-greening measures (A2014) - Gemeenschappelijk landbouwbeleid vergroeningsmaatregelen	Common Agricultural Policy-greening measures 2014-2020	Regional (Flanders)	Policy department of Agriculture and fisheries
A-RD	Common Agricultural Policy-Rural development (A2014) – Vlaams programma voor plattelandsontwikkeling 2014-2020	Common Agricultural Policy - Rural development 2014-2020 (PDPOIII)	Regional (Flanders)	Policy department of Agriculture and fisheries
FECP	Flemish Energy and climate plan 2021-2030 (A9/12/2019) – Vlaams Energie en klimaatplan 2021-2030	2030 Climate & energy framework	Regional (Flanders)	Policy department of Environment
FLS	2050 Flemish long-term climate strategy- Vlaamse klimaatstrategie 2050 (A20/12/2019)	2050 long-term climate strategy	Regional (Flanders)	Policy department of Environment
FAS	2021-2030 Flemish adaptation strategy – Vlaams Adaptatie plan: not approved yet in June 2020 and therefore not included in the analysis.	EU climate change adaptation strategy	Regional (Flanders)	Policy department of Environment
ND	Manure action plan 2019-2022-Zesde actieprogramma in uitvoering van de nitraatrichtlijn 2019-2022 (A2019)	EU Nitrates Directive	Regional (Flanders)	Flemish land agency (VLM)

Policy ID	Policy Name[a]	Corresponding EU policy	Government level	Responsible policy department
DIW*	Decree on Integrated Water policy – Integraal Waterbeleid 2016-2022	EU Water Framework Directive / EU Floods Directive	Regional (Flanders)	Policy department of Environment
SD-E	Soil Decree – Decision on Erosion Control – Bodemdecreet (A2006)– Erosiebesluit (A2009)	n.a.	Regional (Flanders)	Flanders policy department of environment
V50	2050 Vision – a longterm strategy for Flanders – Visie2050 Een langetermijnstrategie voor Vlaanderen (A2016)	n.a.	Regional (Flanders)	Flemish government
SDG30	2030 Vision – 2030 objectives framework for Flanders - Vizier2030 – Een 2030-doelstellingenkader voor Vlaanderen (A2019)	n.a. – UN Sustainable development goals	Regional (Flanders)	Flemish government
BM25	Action plan food loss and biomass (waste) streams 2021-2025- Actieplan voedselverlies en biomassa-(rest)stromen circulaire 2021-2025 (draft working document 10/04/2020)	n.a. links to circular economy and bio-economy	Regional (Flanders)	Flemish waste agency (OVAM)
SUP	Decree on the sustainable use of pesticides and associated decisions - decreet duurzaam gebruik pesticiden en de bijhorende besluiten (A2013)	Sustainable Use of Pesticides Directives	Regional (Flanders) / Federal	Flemish environmental agency
BD	Decree on soil remediation and soil protection – Bodemdecreet (A2006)	n.a.	Regional (Flanders)	Flemish waste agency (OVAM)
MD	Decree on the Sustainable Management of the Life Cycle of Materials and Waste Materialendecreet (A2012)	Waste frame directive, landfill directive, sewage sludge directive	Regional (Flanders)	Flemish waste agency (OVAM)
BRV	Spatial policy plan Flanders - Strategische visie Beleidsplan Ruimte Vlaanderen (A2018)	n.a.	Regional (Flanders)	Flanders policy department of Environment
PN-E	Environment policy note 2019-2024 Beleidsnota Omgeving 2019-2024 (A2019)	n.a.	Regional (Flanders)	Minster of Environment
PN-A	Agriculture and Fisheries policy note 2019-2024 – Beleidsnota Landbouw&visserij (A2019)	n.a.	Regional (Flanders)	Minister of Agriculture and Fisheries

Policy ID	Policy Name[a]	Corresponding EU policy	Government level	Responsible policy department
PN-C*	Climate policy note 2019-2024 – Beleidsnota Klimaat (A2019)	n.a.	Regional (Flanders)	Minster of Environment

n.a.: not applicable

[a]: **A**: date of approval; **D**: date of draft (documents in final phase but not approved by the government yet)

* Added in the validation phase by stakeholders who completed the questionnaire (and thus not included in the questionnaire)

In Belgium most policies affecting agricultural soils and soil management are regional matter. For the region of Flanders most policy documents found correspond to EU policies. For the Nitrates Directive (ND), Flanders is regarded as a Nitrate Vulnerable Zone. Specific for Flanders is the Decree on soil remediation and soil protection (BD) which focuses on soil contamination and soil erosion (SD-E). SD-E is especially on off-site effects with subsidies for small constructions to avoid off-site damage and the financing of erosion coordinators who develop erosion prevention plans at the municipal level. Erosion prevention on farmers' fields is regulated through CAP. Besides the soil decree, the importance of soils is also highlighted in the longer term strategies of Flanders towards 2030 (SDG30) and 2050 (V50), the action plan on Food loss and biomass waste streams 2021-2025 (BM25)[3], the Spatial policy plan (BRV) and the policy notes 2019-2024 (PN-E/PN-A/PN-C).

At the time of the analysis the climate change adaptation plan was not approved in Flanders yet and could not be included. The Decree on Integrated Water Policy is the juridical implementation of the Water Framework Directive (WFD) and the Floods Directive (FD) and constitutes the general framework (organization, planning, instruments) for the integrated water policy in Flanders. However, it was not used in the analysis because for agricultural soils and soil management it relies on other legislation such as the manure action plan (ND), the decree on soil remediation and soil protection (BD), greening measures (A-GM) and CAP-Rural development (A-RD). The Nature Decree implements the European Birds and Habitat Directives but was not included in the analysis because its main aim is to conserve biodiversity and only impacts soil management in some dedicated areas. These measures are also included in the CAP and are mentioned as such in the analysis where appropriate, i.e. the protection of ecological vulnerable grasslands, which includes the grasslands in peat and wetland areas. In Flanders there are no Areas of Natural or other specific constraints (ANC). The Environmental Impact Assessment Directive (EIA) and the Strategic Environmental Assessment Directive (SEA) were also not included in the analysis.

[3] One stakeholder pointed out that BM25 is not new policy but implements other policy initiatives

3.2 Current policy ambitions and realisations

Tables 2 and 3 summarise the necessary information to understand current policy ambitions and realisations on agricultural soils and soil management in Flanders.

An overview of soil related targets that are expressed in policy documents is provided in Table 2, as well as the indicators used to monitor these targets and the current status of the indicators, when available. The table also lists instruments to monitor the targets that are mentioned in the policy documents and that are already used or that need development. Other instruments that are mentioned in the policy documents that are or will be used to reach targets are listed as well. The list of monitoring and other instruments is thus not complete. We mainly focused on what was mentioned in the policy documents screened and instruments that are not well established yet.

In Table 3, the soil related targets set by policy are positioned in a soil challenge – climate-smart sustainable soil management matrix. It shows what soil challenges are targeted by policy and what elements of climate-smart sustainable soil management[4] will be used to reach the targets.

[4] Paustian, K., Lehmann, J., Ogle, S., Reay, D., Robertson, G. P., & Smith, P. (2016). Climate-smart soils. *Nature*, *532*(7597), 49-57.

Table 2: *Summary of policy analysis*

Policy ID	Policy target[a]	Indicators + current status	Policy monitoring tools[b]	Other policy instruments[b]
A-CC	GAEC4/5: Less erosion by water with focus on on-site erosion control (**SAS**) (not quantified) – target is to have 100% of farms compliant with the GAEC measures, but no result based quantified target. Farmers need to take measures on field parcels with (very) higher erosion risk. These measures are depending on crop type and include a.o. soil cover during winter, reduced tillage practices, buffer strips and erosion dams When %C>1.7% +pH is optimal, erosion sensitivity class of the field parcel is lowered	Indicator based on the RUSLE model, crops grown and measures taken for cross compliance, is under development (*remark: this indicator is published in August 2020 after completing of the questionnaire by the stakeholders: the average soil erosion risk decreased from 2.62 ton/ha.year in 2008 to 2.53 ton/ha.year in 2016**)[5].	On a small sample of farms each year, it is checked if measures taken are compliant with the defined measures in GAEC 4 and 5	
A-CC	GAEC 6: target: soil carbon content (% C) of field parcels above minimum threshold, pH in optimal zone (**SAS**) –target is to have 100% of farms compliant with the GAEC measures, i.e. to have the necessary number of soil samples, but no result based quantified target Ban to burn stubbles and harvest residues*		On a small sample of farms each year, it is checked if farmers have the required number of soil analysis results as defined in GAEC 6 but no regional monitoring of carbon and pH	
A-GM	Reference ratio of area permanent grassland (5 years or older) / total area of CAP farmers (excl. organic farmers) in 2015 (based on area data of 2012) should not decrease with more than 5% at the regional level (Flanders) (**SAS**) Designation of ecologically vulnerable permanent grassland (EKBG) both within and outside Natura 2000 areas: plowing and conversion ban. Within Natura2000 areas are the permanent grasslands in peat and wetland areas designated as EKBG.*	Area permanent grassland / total area of CAP farmers (excluding organic farmers): reference ratio 2015 (based on data of 2012) = 27.99%; decreased to 27.28% in the 2016-2018 period; 27.36% in 2019		
A-GM	Crop diversification for a healthy soil. Farmers need to grow 2 or 3 different crop types depending on their cultivated area (**SAS**)			
A-GM	Ecological focus area: Farmers choose in large numbers for sowing a mixture of cover crops*		For the parcel registration farmers need to register measures taken in the single application to fulfill their obligations for the ecological focus area *	
A-RD	Focus area 4C: 1.36% of agricultural land under management contracts to improve soil management and/or prevent soil erosion (maximum to be reached in 2014-2023 period) (**SAS**), e.g. grass strips, strategic grasslands, dams, organic farming. Avoiding erosion: Investment support for non-inversion tillage machinery, direct drilling, micro dam machinery and erosion dams (**SAS**)	Max. % of agricultural land under contract for focus area 4C: 0.98% in the 2014-2018 period		

[5] Swerts, M., Deproost, P., Renders, D., Oorts, K., 2020. Bodemerosierisico-indicator Vlaanderen (2008-2019). Departement Omgeving, Brussel.

Policy ID	Policy target[a]	Indicators + current status	Policy monitoring tools[b]	Other policy instruments[b]
A-RD	Focus area 5D: 1.7% (increased to 2.88% in 2019) of agricultural land under management contracts to reduce greenhouse gas emissions and/or NH_3 (maximum to be reached in 2014-2023 period) (**SAS**), e.g. crops that need less fertilization such as flax and hemp, legume crops	Max. % of agricultural land under contract for focus area 5D: 1.73% in the 2014-2018 period		
A-RD	Focus area 5E: 370 ha of agricultural and forestry land under management contracts to conserve and sequester carbon (2014-2023 period) (**SAS**); i.e. agroforestry (150 ha by 2020) and afforestation of agricultural land (only those partly paid by PDPO means) Supporting carbon sequestration: Investment support for turning compost in a rill and compost/farm yard manure spreader (**SAS**)	Agroforestry 67 ha subsidised in the 2014-2018 period Afforestation: 46 ha subsidized in the 2014-2018 period		
A-RD	Avoiding soil compaction: Investment support low pressure tyres and tyre air pressure system (**SAS**)			
A-RD	Organic farming: 5300 ha organic + 2100 ha under conversion by 2020 **(NS)**	2018: 3808 ha organic farming and 2030 ha under conversion subsidised		
FECP	Agricultural sector: soil emissions (N_2O) should decrease with 0.27 Mton CO_2eq = 19% by 2030 compared to 2005 (**SAS**)	N_2O-emissions kton CO_2eq (1359 kton CO_2eq in 2017, i.e. -4.8% in 2017 vs 2005, i.e. -0.07Mton CO_2eq in 2017 vs 2005)		- Climate scan at farm level (**I**) *(currently a project starting off with dairy farms https://www.klimrekproject.be/*)
FECP	LULUCF: no debit in 2021-2030 period (**NS**) LULUCF: more carbon storage in agricultural soils (**SAS**), by protection carbon rich soils and long existing grasslands and to foster carbon sequestration*.	- Carbon stock (0-1m Mton) (not monitored yet) - Carbon stock (0-1m Mton) (not monitored yet)	- LULUCF: Soil carbon monitoring network (**P**)	- LULUCF action plan (**I**) - LULUCF: Flemish carbon market (**I**) (including soil carbon sequestration) or other valorisation of C-sequestration through CAP or market based initiatives (**I**)
FLS	Agricultural sector: -40% non-energetic greenhouse gas (GHG) emissions by 2050 compared to 2005 (**NS**) (indicative but non-binding target)	+3.2% non-energetic GHG expressed in CO_2 eq. in 2018 compared to 2005		Business models for valorisation of ecosystem services such as carbon sequestration, water retention and infiltration (**I**)
FLS	C-content of agricultural soils is in optimal zone by 2050 and C-content further increases or remains at high level (**SAS**) Carbon hotspots (peat areas and alluvial forest) are protected by 2050 and disturbed systems are being recovered(**SS**)		- Better carbon monitoring needed to estimate reduction potential, mapping of carbon hotspots	Business models for valorisation of ecosystem services such as carbon sequestration, water retention and infiltration (**I**) Financial mechanism to stimulate carbon sequestration, a.o; CAP (**I**)
ND	-Threshold values for residual nitrate at the field parcel level between 1/10 and 15/11 as indicator for the nitrate leaching risk in winter; threshold values are depending on crop type, soil texture and water quality area (60-90 kg nitrate-N/ha from 0-90 cm) (**SAS**)	- Weighted average residual nitrate (kg nitrate-N/ha in the 0-90 cm layer): 2004: 111 kg nitrate-N/ha – 2018: 89 kg nitrate-N/ha	Monitored by measuring residual nitrate in autumn on a selection of field parcels.*	-Action plan to increase soil organic matter with respect for P leaching risk (**I**); -Soil passport (**I**)

Policy ID	Policy target[a]	Indicators + current status	Policy monitoring tools[b]	Other policy instruments[b]
	- To steer P availability in the soil towards a target zone for soil fertility and limited environmental risks (**SAS**) -- Aim to increase soil quality by stimulating measures that increase soil organic matter content (**SAS**), e.g. cover crops, farmyard manure, (farm) compost - Residual nitrate levels are for field or farm level control; Policy targets are not soil related but relate to water quality (a.o. yearly average of 18 mg nitrate/l in surface waters). Since MAP 6 (Manure action plan 2019-2022), the mean nitrate concentration is considered per run-off zone. The target value is an average of 18mg nitrate/l surface water. By the end of 2022, the target distance should be decreased by 4 mg nitrate/l. For ground water the aim is to have a decreasing trend of at least 0.75 mg nitrate/l.year in run-off zones where ground water quality is not ok yet*.	>70% of agricultural field parcels has available P content above the target of 18 mg P/100 g air dry soil in 2019 (note: this does not include parcels without analysis)) example: average nitrate concentration in surface waters in agricultural area 20.6 mg nitrate-N/l in 2018-2019	only monitored indirectly by monitoring some measures : area of catch crops and use of stable manure and compost (only half of P use has to be taken into account for some fields in order to increase soil organic carbon content) Average nitrate concentration in surface waters is measured via MAP-network* Control of measures taken by farmers such as area of cover crops, tracking system for transport of animal manures with GPS, flow meters, farm checks*	-Code best and innovative fertilisation practices to improve water quality (yearly updated) (**I**) Awareness and advisory services for nutrient management and soil care **(I)*** **WATER+LAND+SCHAP (P)*:** programme to stimulate realisations in the field to target multiple policy goals (nutrient leaching, SOC, soil quality, erosion, water quantity and quality) **A-RD**: agro-environmental scheme 'water quality' (**E**)*: nutrient and carbon management
SD-E	Aim is to lower off-site erosion damage– no quantified target **(SAS).** Municipalities are supported to realise erosion control measures*	Indicator sediment yield to surface waters and sewerage in preparation (modelling with CN-WS)*		Erosion coordinators, municipal erosion control plans (**E**), municipal erosion control measures (**E**) * **A-RD**: agro-envrionemental scheme erosion control (**E**)*
V50	Natural capital (biodiversity, land, air, water and soil) of Flanders is restored and protected by 2050; society values land, soil and subsoil as much as air and water quality by 2050; land degradation is stopped by 2050 (**SS**); the food production system helps to preserve water, land and biodiversity (**SAS**)			
SDG30	Land degradation neutrality by 2030 in Flanders (net no extra degraded land) (**SS**)	3 indicators: - Soil sealing (area artificial soil covering/total area): 16% in 2015 (**SS**) - Number of polluted soils per sanitation phase (not specific for agricultural soils) (**SS**) - Soil erosion status **(SAS):** indicator under development		
BM25	-Maintaining and increasing soil organic carbon content of the soil by 2025 (**SS**) by			

Policy ID	Policy target[a]	Indicators + current status	Policy monitoring tools[b]	Other policy instruments[b]
	• Increasing supply of digestable and compostable residues for production or organic soil amendments and fertilizers • Stimulating the use of organic soil amendments and fertilizers by multiple users including agriculture • Increasing the supply of woody residues by stimulating the cooperation for management of landscape elements and forests • Stimulating on-farm composting by removing barriers in legislation by 2022 • Stimulating the use of wood chips as soil amendments by removing barriers in legislation by 2022 -Protecting global peatlands by stimulating renewable substrates for consumers and horticulture (**SS**)			
SUP	Regulating the sustainable use of pesticides, implicitly aiming to reduce the impact on soil, soil contamination and water (**SS**); To ensure that type (licensed), amount and concentrations of pesticides used in agriculture is in line with guidelines for good agricultural practices (**SAS**)		Flemish biomonitoring to detect diffuse contamination such as contamination by crop protection substances in humans, soils, vegetables and air (**I**)	Fytoweb*
BD	Prevention and remediation of soil contamination and clean-up historical contamination by 2036 (**SS**) Regulates re-use of excavated soil materials in order to reduce impact on the environment including soils (**SS**)*		Mapping diffuse soil contamination, including in agricultural soils and establishing regulation (**I**) Land information register (LIR) which contains all known data on soil contamination in Flanders (**E**)	
MD	Regulates use of waste and materials (including sewage sludge) as fertilizer or soil improving substances in order to reduce impact on the environment including soils (**NS**)			
BRV	% sealed surface -20% by 2050 compared to 2015 in land use categories agriculture, nature and Forest (**SS**) Target of net zero land take by 2040* (**SS**)	Settlements is 33%; land take rate: ca 6ha/day in 2016*	For agricultural areas a monitoring system is being developed with aerial photographs and artificial intelligence (**P**).* Reduction of land take monitored by the evolution of the settlement area in Flanders*	
PN-E	Soils in Flanders may not loose carbon in the upcoming 10 years (2020-2030) (**SS**). Therefore, carbon loss from agricultural soils is strongly reduced (**SAS**). It is investigated how to make soils and soil use more climate proof with special attention to drought and excess of water (**SS**).		Soil carbon monitoring network (**P**)	
PN-A	Farmers are supported to maintain and improve soil quality. The focus is on organic carbon (eg by applying compost and farmyard manure), decreasing nitrate and phosphorus concentration that are too high in soil and increasing water holding capacity of soils (**SAS**)		Soil carbon monitoring network (**P**)	Soil passport (**I**) and stimulating soil scans and smart measuring systems to facilitate data driven farm management and the use of decision support tools

Policy ID	Policy target[a]	Indicators + current status	Policy monitoring tools[b]	Other policy instruments[b]
	Soils in Flanders may not loose carbon in the upcoming 10 years (2020-2030) (**SS**). Therefore, carbon loss from agricultural soils is strongly reduced (**SAS**).			Data platform DjustConnect (**P**)
PN-C*	Soils in Flanders may not loose carbon in the upcoming 10 years (2020-2030) **(SS)** loss of carbon from agricultural soils is strongly reduced (**SAS**)*. Nutrient cycles are closed and we aim at storing carbon as long as possible in soil and biomass, by, a.o. extracting more bio-waste from waste fractions for composting or digestion. (**NS**)*		Soil carbon monitoring network (**P**)*	For agricultural soils the policy note refers to instruments of the new CAP (**P**)* An advisory system will be established for integrated soil management (a.o. C storage) and fertilization (**I**)*

[a]: **SS**: soil specific; **SAS**: specific for agricultural soils only; **NS**: non-soil specific, the target includes soils but is broader than agricultural soils only

[b]: **E**: already established (already or nearly operational); **P**: in progress (it is already (quite) well known how to develop and development is in progress); **I:** initial development phase or development or research phase still has to start

* Added in the validation phase by stakeholders who completed the questionnaire (and thus not included in the questionnaire)

Table 3 *Policy packages and targets positioned in a soil challenge – 'elements of climate smart sustainable soil management' cross table*

	Improved water storage and water use efficiency	**Control soil erosion and land degradation**	**Improved soil biodiversity**	**Improved soil structure management**	**Improved nutrient management**	**SOM management for C sequestration**
Maintain/increase SOC		**A-CC:** When %C>1.7% +pH is optimal, erosion sensitivity class of the field parcel is lowered				**A-CC**: soil carbon content (% C) of field parcels above minimum threshold – ban to burn stubbles and harvest residues*; **A-GM**: Reference ratio of area permanent grassland in 2015 should not decrease with more than 5% at the regional level (Flanders) – ban to convert ecological vulnerable permanent grasslands*; **A-GM**: green cover/catch crops (as ecological focus area)*; **A-RD**: 150 ha by 2020 under agroforestry; **A-RD**: 370ha of agricultural and forestry land under management contracts to conserve and sequester carbon by 2023, i.e. agroforestry 150 ha and afforestation; **A-RD:** investment support composting/manure spreader; **FECP-** LULUCF: no debit in 2021-2030 period (**NS**); more carbon storage in agricultural soils (**SAS**); **FLS**: C-content of agricultural soils is in optimal zone by 2050 and C-content further increases or remains at high level (**SAS**); Carbon hotspots (peat areas and alluvial forest) are protected by 2050 (**SS**); **ND:** stimulating measures that increase soil organic matter content; **BM25:** Maintaining and increasing soil organic carbon content of the soil by 2025 (**SS**); **PN-A/PN-E/PN-C**: Soils in Flanders may not loose carbon in the upcoming 10 years (2020-2030) (**SS**); carbon loss from agricultural soils is strongly reduced (**SAS**). **PN-C:** Nutrient cycles are closed and we aim at storing carbon as long as possible in soil and biomass, by, a.o. extracting more bio-waste from waste fractions for composting or digestion. (**NS**)
Avoiding N_2O, CH_4 emissions					**A-RD**: 2.88% of agricultural land under management contracts to reduce greenhouse gas emissions and/or NH_3 (2014-2023); **FECP***:* soil emissions (N_2O) - 19% by 2030 vs 2005 (**SAS**); **FLS**: Agricultural sector: -40% non-energetic GHG emissions by 2050 vs 2005 (**NS**)	
Avoid peat degradation	**FLS:** Carbon hotspots (peat areas and alluvial forest) are protected by 2050 and disturbed systems are being recovered(**SS**); **A-CC:** Vegetation decision: protection of peat and wetland areas*					**A-GM:** protection of permanent grasslands in peat and wetland areas*; **BM25**: Protecting global peatlands by stimulating renewable substrates for consumers and horticulture
Avoid soil erosion		**A-CC:** Less erosion by water with focus on on-site erosion control; **A-RD** 1.36% of agricultural land				

	Improved water storage and water use efficiency	Control soil erosion and land degradation	Improved soil biodiversity	Improved soil structure management	Improved nutrient management	SOM management for C sequestration
		under management contracts (2014-2023; **A-RD:** investment support for erosion prevention machinery and erosion dams; **SD-E** to lower off-site erosion damage **SDG30:** land degradation neutrality by 2030, indicator erosion (SAS)				
Avoid soil sealing		**SDG30**: land degradation neutrality by 2030 with soil sealing as one of the indicators (SS); **BRV**: % sealed surface -20% by 2050 compared to 2015 in land use categories agriculture, nature and Forest (**SS**) – net zero land take by 2040 (**SS**)*				
Avoid salinisation						
Avoid acidification		**A-CC:** When %C>1.7% +pH is optimal, erosion sensitivity class of the field parcel is lowered		**A-CC**: pH in optimal zone		
Avoid contamination		**SDG30**: land degradation neutrality by 2030 with contamination as one of the indicators (SS); **SUP**: Regulating the sustainable use of pesticides, (**SS**); **BD**: Prevention and				

	Improved water storage and water use efficiency	Control soil erosion and land degradation	Improved soil biodiversity	Improved soil structure management	Improved nutrient management	SOM management for C sequestration
		remediation of soil contamination and clean-up historical contamination by 2036 (**SS**) – regulated reuse of excavated soil materials to reduce impact on the environment including soils*; **MD**: Regulates use of waste and materials (including sewage sludge) as fertilizer or soil improving substances (**NS**)				
Optimal soil structure				**A-RD:** Avoiding soil compaction: Investment support low pressure tyres and tyre air pressure system. **A-CC**: pH in optimal zone*; **A-GM**: green cover/catch crops (as ecological focus area)*;		**A-CC**: soil carbon content (% C) of field parcels above minimum threshold, pH in optimal zone (**SAS**)*
Enhance soil biodiversity			**A-GM** crop diversification			**FECP-** LULUCF: no debit in 2021-2030 period (**NS**)*; more carbon storage in agricultural soils (**SAS**)*; **FLS**: C-content of agricultural soils is in optimal zone by 2050 and C-content further increases or remains at high level (**SAS**)*; **ND:** stimulating measures that increase soil organic matter content*
Enhance soil nutrient retention/use efficiency					**ND**: threshold values for residual nitrate-N in autumn at field parcel level; To steer P availability in the soil towards a target zone for soil fertility and limited environmental risks (**SAS**)	**FECP-** LULUCF: no debit in 2021-2030 period (**NS**)*; more carbon storage in agricultural soils (**SAS**)*; **FLS**: C-content of agricultural soils is in optimal zone by 2050 and C-content further increases or remains at high level (**SAS**)*; **ND:** stimulating measures that increase soil organic matter content*
Enhance water storage capacity	**PN-E**: how to make soils and soil use more climate proof with special attention to drought and excess of water (SS); **PN-A**: increasing water holding capacity of soils (SAS)					**FECP-** LULUCF: no debit in 2021-2030 period (**NS**)*; more carbon storage in agricultural soils (**SAS**)*; **FLS**: C-content of agricultural soils is in optimal zone by 2050 and C-content further increases or remains at high level (**SAS**)*; Carbon hotspots (peat areas and alluvial forest) are protected by 2050 (**SS**)*; **ND:** stimulating measures that increase soil organic matter content*

	Improved water storage and water use efficiency	Control soil erosion and land degradation	Improved soil biodiversity	Improved soil structure management	Improved nutrient management	SOM management for C sequestration
Other		**SDG30**: land degradation neutrality by 2030; **V50** stop land degradation in general by 2050				

* Added in the validation phase by stakeholders who completed the questionnaire (and thus not included in the questionnaire)

In Flanders, most policies that affect agricultural soils and soil management are regional matter and many are derived from EU policies. Specific for Flanders is the Decree on soil remediation and soil protection (BD) which focuses on soil contamination and soil erosion (SD-E). Besides, the importance of soils is also highlighted in longer term strategies, the spatial policy plan, policy notes and action plans. Despite the fact that soils are mentioned and targeted in many policies, an overarching soil policy framework is missing in Flanders.

Soil targets

In Flanders the largest focus in policy is on soil organic carbon, soil erosion, soil contamination, and nutrient retention/use efficiency. The most important targets for these soil challenges are:

- **Soil organic carbon**: Targets for the LULUCF sector as a whole in the 2021-2030 period are no debit; for agricultural soils there is a non-quantified and non-binding target, i.e. more carbon storage in agricultural soils (FECP). Also in the long term climate strategy (FLS) there is a target specifically for agricultural soils, i.e., C-content of agricultural soils is in optimal zone by 2050 and C-content further increases or remains at high level.
- **Soil erosion**: the aim of SD-E is to lower off-site erosion damage, but this target is not quantified. On field parcels with (very) high erosion risk, A-CC requires farmers to take measures to mitigate erosion on-site (eg cover crops/non-inversion tillage) or off-site (eg buffer strips). There is a recent indicator[6] for monitoring the erosion risk based on modelling with inputs such as topography, crop types and measures taken, but there are no quantified targets. SDG30 aims at no extra land degradation by 2030 including no erosion, but no monitoring methods or thresholds are set yet.
- **Nutrient use** is regulated through the manure decree (ND). There are targets for water quality and for soil there are targets for individual field parcels, i.e. soil residual nitrogen in autumn and available phosphorus.
- Legislation on **soil contamination** is quite elaborated in Flanders. For agricultural soils there is regulation on the use of pesticides and the use of waste and materials to be used as fertilizer or soil improver. Targets are not specific for agricultural soils only.

Some other soil challenges with targets are:

- **N_2O emissions** from agricultural soils: emissions need to be reduced with 19% by 2030 compared with 2005 (FECP);
- **Soil sealing**: % sealed surface -20% by 2050 compared to 2015 in the land use categories agriculture, nature and Forest (BRV);
- The target to reach **land degradation neutrality** includes soil erosion, sealing and contamination but no clear targets and indicators are defined yet;
- Carbon hotspots (**peat** and alluvial forests) need to be protected by 2050 and disturbed systems should be recovered (FLS);

For **acidification** farmers need to take soil samples for A-CC and take actions but the results of these analyses and the actions taken are not monitored. There are no clear policy targets yet on **soil salinization, enhancing water storage capacity and soil structure**. The targets on **enhancing soil biodiversity** are only indirect because farmers need to diversify their crops for A-GM in function of healthy soils.

Monitoring of soil challenges

In Flanders, farmers need to take frequent soil samples for various policies (e.g., ND, A-CC) but there is **little soil monitoring at the regional level**, so little is known on the evolution of the soil challenges. Currently, there is no systematic statistically-sound soil monitoring on-going.
For CAP (A-CC), farmers need to take the necessary samples for %C and pH, but the results remain at the farm. For the LULUCF inventory, standard emission factors are used that are based on older studies, so actual data are needed. A **soil carbon** monitoring network is designed (Sleutel et al., 2021)[7] and the establishment is a policy ambition (FECP, PN-E/A/C), but measurements still need to start. For the manure decree (ND) farmers need to take soil samples for residual soil nitrate in autumn and available P status and the evolution in **weighted average soil residual nitrate** is monitored as well as the **% of field parcels with available P content above the target**. **N_2O emissions** from soils are calculated for the climate emission inventory based on basic IPCC Tier 1 rules. In September 2020, a new **soil erosion indicator** was launched to monitor the evolution in soil erosion risk based on a modelling approach taking into account the potential soil erosion risk of field parcels, the erosion sensitivity of crops grown and an estimation of measures taken by farmers (Swerts et al., 2020).
Regarding soil contamination, a Flemish biomonitoring to detect **diffuse contamination** such as by crop protection substances in humans, soils, vegetables and air is under development as well as mapping of diffuse contamination in agricultural soils. In Flanders there is also a **land information register** which contains all known data on soil contamination in Flanders.

Policy instruments that are foreseen and need further (research) development

Currently, a **climate scan** at the farm level (mentioned by FECP) is being developed and a soil carbon module will be included (www.klimrekproject.be).
A **LULUCF action plan** will be developed and the Flemish Energy and Climate Plan (FECP) mentions the establishment of a **Flemish carbon market** including soil carbon sequestration or other valorisation through CAP or market-based initiatives. FLS mentions **business models for valorisation of ecosystem services** such as carbon sequestration, water retention and infiltration. These instruments are still at the initial phase or development still has to start.
ND mentions that an action plan to increase SOM, taking into account the P leaching risk, will be developed. There is also a yearly update of a **code best and innovative fertilisation practices** to improve water quality. The **soil passport,** currently under development by the policy department for agriculture and ILVO, is mentioned by PN-A and ND, that also stress the need to stimulate soil scans and smart measurement systems to facilitate **data driven farm management** and the **use of decision support tools**. In Flanders, a **dataplatform DjustConnect** is being developed that allows agricultural data exchange (www.djustconnect.be).

3.3 Soil management practices as mentioned in policy documents

In Table 4, management practices that are mentioned in the policy documents for reaching soil related or other targets are indicated. The table also shows what soil or other environmental challenges the policy wants to address by encouraging the management practice. All management practices mentioned in the policy documents are listed regardless of the fact if they are mandatory or will be encouraged on a voluntary basis with or without economic incentives.

[6] Swerts, M., Deproost, P., Renders, D., Oorts, K., 2020. Bodemerosierisico-indicator Vlaanderen (2008-2019). Departement Omgeving, Brussel.
[7] Sleutel S., D'Hose T., Lettens S., Ruysschaert G., De Vos B. 2021. ACTUALISATIE EN VERFIJNING VAN DE ONDERBOUWING VAN EEN METHODIEK VOOR DE SYSTEMATISCHE MONITORING VAN KOOLSTOFVOORRADEN IN DE BODEM (opdracht OMG/VPO/BODEM/TWOL/2017/1) – Eindrapport. Vlaams Planbureau voor Omgeving, Brussel.

Table 4: *Overview of management practices, grouped into seven land management categories, listed in the policy packages and purpose of the policy package*

	Maintain/increase SOC	**Avoid N_2O/CH_4 emissions**	**Avoid peat degradation**	**Avoid soil erosion**	**Avoid soil sealing**	**Avoid salinisation**	**Avoid acidification**	**Avoid contamination**	**Optimal soil structure**	**Enhance soil biodiversity**	**Enhance nutrient retention/use efficiency**	**Enhance water storage capacity**	**Other environmental stakes**
Crops/rotations													
More cereals	FECP; FLS			FLS								FLS	
More legume crops		A-RD; FECP											A-GM
More grassland	ND			ND							ND		ND
Intercropping/multiple cropping													
Cover/catch crops	FECP; FLS; A-GM			A-CC; FLS							ND*	FLS	A-GM (mixtures); ND
Perennial crops	FECP; FLS			FLS								FLS	
Permanent grazing													
Rotational grazing													
Zero grazing													
Other: Keeping permanent grasslands	A-GM: >= 95% of reference area – regional level; FECP; FLS (incl. optimize management when c- rich)			A-CC; A-RD								FLS	A-GM
Other: crop diversification on farm level													A-GM (soil health)
Other: flax and hemp		A-RD											
Other: fodder with low protein content		FECP; FLS											
Other: one cut of grass before maize													ND
Other: grass under main crop											ND* (considered as catch crop)		A-GM; ND* (considered as catch crop)
Other: legume under main crop													A-GM
Other: crops with high effective organic carbon	A-RD												
Other: crops with low risk for N leaching													A-RD; ND
Other: crops that are less sensitive for erosion				A-RD									

	Maintain/increase SOC	Avoid N_2O/CH_4 emissions	Avoid peat degradation	Avoid soil erosion	Avoid soil sealing	Avoid salinisation	Avoid acidification	Avoid contamination	Optimal soil structure	Enhance soil biodiversity	Enhance nutrient retention/use efficiency	Enhance water storage capacity	Other environmental stakes
Other: fallow													A-GM
Other: short rotation coppice													A-GM
Other: orchard													A-CC
Other: ban to burn stubbles and crop residues*	A-CC*												
Tillage and traffic													
No till				A-CC; A-RD									
Non-inversion/reduced tillage				A-CC; A-RD									
Deep ploughing													
Contour ploughing													
Terrace farming													
Controlled traffic farming													
Low pressure (in) tires									A-RD				
Decision support system for risk of soil compaction													
Other: rubber tracks									A-RD				
Other: strip-tillage				A-CC; A-RD									
Other: contour sowing				A-CC									
Other: micro dams or tine tillage in between ridges of potato or vegetables				A-CC; A-RD									
Organic matter/nutrient management													
Reduced/more precise mineral fertiliser application		FECP; FLS									FECP; FLS; ND		ND
Appropriate compost application	FECP; FLS; ND (including on-			FLS								FLS	

	Maintain/increase SOC	Avoid N_2O/CH_4 emissions	Avoid peat degradation	Avoid soil erosion	Avoid soil sealing	Avoid salinisation	Avoid acidification	Avoid contamination	Optimal soil structure	Enhance soil biodiversity	Enhance nutrient retention/use efficiency	Enhance water storage capacity	Other environmental stakes
	farm composting); A-RD; BM25; PN-A;												
Appropriate farmyard manure application	FECP; FLS; ND; A-RD; PN-A			FLS								FLS	
Biochar application													
Incorporation of crop residues	A-CC (prohibition to burn stubble/residues); FLS			A-CC: leave residues on surface; FLS					A-CC (prohibition to burn stubble/residues)		A-CC (prohibition to burn stubble/residues)	FLS	
Fertilisation plan/advice											ND		ND
Better manure storage													FECP (GHG during storage)
Manure treatment									FLS		ND*		FECP (GHG during storage); FLS; ND
Valorisation of waste streams	FECP; FLS; BM25; PN-C*								FECP; FLS				
Enhanced weathering	FECP												
Other: green soil cover				A-CC: >80% green cover for perennial crops									A-GM: green cover (ecological focus area)*
Other: Better management of crop residues													ND
Other: mechanical termination of cover crops, ao roller crimper				A-RD									
Other: liming									A-CC		A-CC		
Other: zero fertilisation													A-RD
Other: P-mining											ND*		A-RD;ND*
Other: restricted N and P fertilisation											ND		ND
Other: digestate	BM25												
Other: wood chips	FLS; BM25			FLS								FLS	

	Maintain/increase SOC	Avoid N_2O/CH_4 emissions	Avoid peat degradation	Avoid soil erosion	Avoid soil sealing	Avoid salinisation	Avoid acidification	Avoid contamination	Optimal soil structure	Enhance soil biodiversity	Enhance nutrient retention/use efficiency	Enhance water storage capacity	Other environmental stakes
Other: renewable substrates			BM25										
Crop protection													
Mechanical weeding													A-RD
Precision herbicide application													
Other: appropriate use of pesticides								SUP					
Other: integrated pest management								SUP					
Water management													
Irrigation													
Subsurface drainage													
Increasing water tables													
Allow flooding													
Other: buffer basin/retention ponds	FLS			A-CC; SD-E								FLS	ND
Other: earth dam with erosion pool				A-CC; SD-E									
Other: plant based dams				A-CC; A-RD									
Other: constructed wetlands												A-RD	ND
Other: small scale water infrastructure general												A-RD	
Buffer strips/small landscape elements													
Grass buffer strips	FLS			A-CC; A-RD; SD-E								FLS	A-GM; A-RD
Other buffer strips	FLS											FLS	A-GM-A-RD (ao Lucerne strips; flowers)
Hedges													A-CC; A-GM;A-RD
Other: tree rows													A-CC; A-GM; A-RD
Other: pollard trees													A-RD
Other: wood edges													A-CC; A-GM; A-RD

	Maintain/increase SOC	Avoid N_2O/CH_4 emissions	Avoid peat degradation	Avoid soil erosion	Avoid soil sealing	Avoid salinisation	Avoid acidification	Avoid contamination	Optimal soil structure	Enhance soil biodiversity	Enhance nutrient retention/use efficiency	Enhance water storage capacity	Other environmental stakes
Small landscape elements in general	FLS											FLS	
Agricultural systems													
Organic farming								SUP					A-GM; A-RD: 5300 ha organic + 2100 ha under conversion by 2020
Agro-ecological farming													V50 (sustainability in general)
Precision agriculture		FECP*; FLS*									ND*		V50; A-RD
Agroforestry	A-RD: 150 ha by 2020; FECP; FLS			A-RD: 150 ha by 2020 (wind)							A-RD: 150 ha by 2020 (wind)	FLS	A-GM
Conservation agriculture													
Other: afforested areas	A-RD												A-GM
Other: transparency and use of big data													V50
Other: smart and data driven farming													PN-A (sustainability in general)

* Added in the validation phase by stakeholders who completed the questionnaire (and thus not included in the questionnaire)

Based on Table 4, Figure 1 provides an overview of the relative share of land management categories to which the mentioned management practices belong.

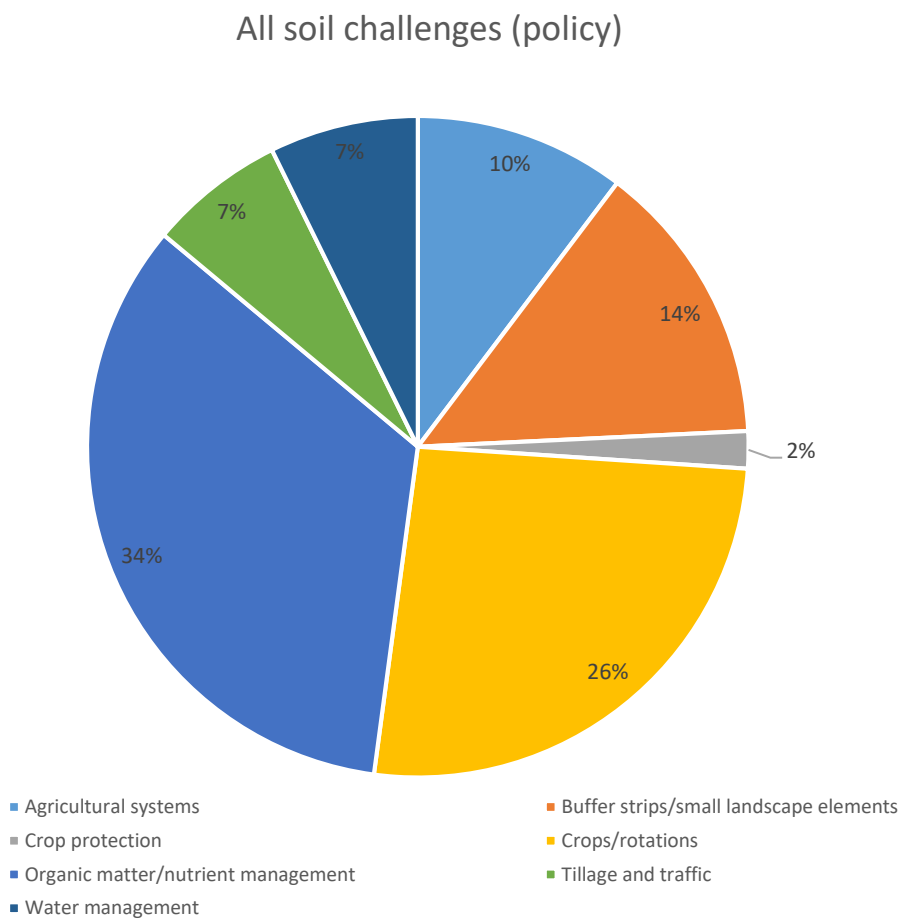


Figure 1 *Relative share of land management categories mentioned in policy documents in Flanders, summarized across all soil challenges.*

Of all management practices mentioned in policy documents, 60% belong to the categories **crop choice/rotations** and **organic matter/nutrient management** and are indicated to be important for multiple soil challenges, i.e., maintaining/increasing SOC, avoiding N_2O emissions, avoiding soil erosion, enhancing soil structure, enhancing water storage capacity, enhancing nutrient retention/use efficiency and other environmental stakes such as water quality and biodiversity. Small scale water infrastructures, **buffer strips** and **small landscape elements** (14%) are used or suggested to prevent off-site erosion effects, to enhance water storage, to increase soil organic carbon and to serve other environmental stakes such as water quality. Adjusting **tillage** practices is regarded to be important to avoid soil erosion and enhance an optimal soil structure. Organic farming and agroforestry are mentioned as **agricultural systems** (10%) with some modest targets. In longer term vision documents also agro-ecological farming and precision farming, as well as transparency and use of big data is mentioned as the way forward.

Compost application is the most mentioned practice. But also farmyard manure application, agroforestry, grass buffer strips, cover crops, permanent grasslands and incorporation of crop residues are seen as good practices by policy to tackle various soil challenges.

4. Stakeholder views on current realisations and future aspirational goals

As outlined in section 2.2, in phase 2, key stakeholder have completed a questionnaire, consisting of 4 main steps: (i) policy analysis validation, (ii) assessing policy realisation and defining aspirational goals, (iii) how to achieve aspirational goals and (iv) policy prioritization. The questionnaire that was sent to the stakeholders is added to Annex II.

4.1 Policy realisation and aspirational goals

The soil policy assessment of phase 1 (Chapter 3) provides an overview of the current policy ambitions. For some policy targets, indicator values are available that track the current status of policy targets, but that is not the case for all policy targets.

In Table 5, the potential gap between the current realisation of the policy ambitions and the targets were scored by the stakeholders. At the same time, the stakeholders also provided their opinions whether the current policy ambition is sufficient in light of the societal challenges (climate change, land and soil degradation, loss of ecosystem services) that we face towards 2050.

Although it was intended that stakeholders would score per soil challenge, some stakeholders scored per policy target. When this was the case, each score equalled '1/number of scores' so that the sum of all scores per soil challenge and per question (current realisations or policy target futureproof) was one for that stakeholder. After, when compiling the results of all stakeholders, the proportion of votes (%) of every scale category was calculated per soil challenge and per question. These scores and a summary of argumentations per soil challenge are provided in Table 5.

Table 5 *Current policy realisations and aspirational goals per soil challenge*

Soil challenge	Current policy target	Current status of policy targets (when indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Number of answers (N)	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Number of answers (N)
			1	2	3	4	5		1	2	3	4	
			Very large	*Large*	*Halfway*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
Maintain/increase SOC	**A-CC**: soil carbon content (% C) of field parcels above minimum threshold, pH in optimal zone (**SAS**) Ban to burn stubbles and harvest residues* **A-CC**: When %C>1.7% +pH is optimal, erosion sensitivity class of the field parcel is lowered (**SAS**) **A-GM**: Reference ratio of area permanent grassland (5 years or older) / total area of CAP farmers (excl. organic farmers) in 2015 (based on area data of 2012) should not decrease with more than 5% at the regional level (Flanders) (**SAS**) ban to convert ecological vulnerable permanent grasslands* **A-RD**: Focus area 5E: 370 ha of agricultural and forestry land under management contracts to conserve and sequester carbon (2014-2023 period) (**SAS**); i.e. agroforestry (150 ha by 2020) and afforestation of agricultural land (only those partly paid by PDPO means) **FECP**: LULUCF: no debit in 2021-2030 period (**NS**); more carbon storage in agricultural soils (**SAS**) **FLS**: C-content of agricultural soils is in optimal zone by 2050 and C-content further increases or remains at high level (**SAS**); Carbon hotspots (peat areas and alluvial forest) are protected by 2050 and disturbed systems are being recovered(**SS**) **ND:** to increase soil quality by stimulating measures that increase soil organic matter content (**SAS**), e.g. cover crops, farmyard manure, (farm) compost **BM25:** Maintaining and increasing soil organic carbon content of the soil by 2025 (**SS**) **PN-A/PN-E**: Soils in Flanders may not loose carbon in the upcoming 10 years (2020-2030) (**SS**). Therefore, carbon loss from agricultural soils is strongly reduced (**SAS**). **PN-C**: idem as in PN-A/PN-E* **PN-C:** Nutrient cycles are closed and we aim at storing carbon as long as possible in soil and biomass, by, a.o. extracting more bio-waste from waste fractions for composting or digestion. (**NS**)*	reference ratio = 27.99%; 27.36% in 2019 Agroforestry 67 ha subsidised in the 2014-2018 period Afforestation: 46 ha subsidized in the 2014-2018 period	*36%*	42%	*11%*	*10%*	*1%*	N=9	*15%*	*13%*	*63%*	*8%*	N=9
			Argumentations: One stakeholder thinks that loss of carbon from agricultural soil is stopped, but four other stakeholders assume that carbon is still being lost from agricultural soils. Evidence from a soil carbon monitoring network is lacking, but this is indicated by analysis results from the Belgian Soil Service (half of the agricultural soils would have a carbon content below the threshold value for soil fertility). They point out that this **loss first needs to be stopped**. One of them thinks that bold choices will need to be made that can be against the short term economic profitability. This might create tensions. Another stakeholder confirms that decreasing C losses towards no debit is possible but that large increases in soil C will be more difficult. One stakeholder thinks carbon sequestration is not lucrative for the farmer on a short-term perspective, current policy has short comings in application and **financial reimbursement/gain**. Two stakeholders point out that the gap is large or very large because the **manure decree limits the possibilities to increase soil C** (*due to limited animal manure application*). One of them thinks the obligation to grow cover crops can be positive under the condition that the cover crops can be sown under optimal conditions. One of the stakeholders points out that few farmers comply with the requirements to lower one erosion class (A-CC) based on %C. Two stakeholders think the **minimum thresholds for soil carbon content are too low (A-CC)** and one of them points out that there is no control on the actions taken by the farmers when carbon content is below the minimum threshold level. One of them also wonders what the **optimal zone** should be for the target pointed out in FLS.							**Argumentations** A-CC (%C of field parcels above minimum threshold) is not futureproof because the current thresholds are too low. One stakeholder thinks that the permanent grassland area should increase (A-GM) and that the indicator is not correct. Some policy targets need better quantification such as ND and BM25. Three stakeholders think an **increase in carbon stocks is needed instead of no-debit** (FECP-PN-A/PN-E), this is in line with FLS. Carbon contents in Flanders are low and reaching an optimal level should be the long term aim in general. Two stakeholders think that in general current policies are not futureproof because **proper policy to increase carbon contents is not in place**. Control is limited (A-CC) and little to no **policy or market driven incentives**. One of the stakeholders expects that the policy will change due to the recent Green deal. One stakeholder beliefs it is desirable that that keeping permanent **grasslands** longer (*at the same area*) is financially stimulated and also thinks it is important that **agroforestry and afforestation** of agricultural land is a voluntary measures and supported financially. One of the stakeholders points out that there are many ways to increase SOC and that not all possibilities are fully utilised yet. Another stakeholders thinks that a good soil quality will get more and more important. Increasing soil carbon is important to increase soil quality.					

Soil challenge	Current policy target	Current status of policy targets (when indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Number of answers (N)	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Number of answers (N)
			1	2	3	4	5		1	2	3	4	
			Very large	*Large*	*Halfway*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
Avoiding N_2O, CH_4 emissions from soils	**A-RD**: Focus area 5D: 1.7% (increased to 2.88% in 2019) of agricultural land under management contracts to reduce greenhouse gas emissions and/or NH_3 (maximum to be reached in 2014-2023 period) (**SAS**), e.g. crops that need less fertilization such as flax and hemp, legume crops **FECP**: Agricultural sector: soil emissions (N_2O) should decrease with 0.27 Mton CO_2eq = 19% by 2030 compared to 2005 (**SAS**) **FLS**: Agricultural sector: -40% non-energetic greenhouse gas emissions (GHG) by 2050 compared to 2005 (**NS**) (indicative but non-binding target)	Max. % of agricultural land under contract for focus area 5D: 1.73% in the 2014-2018 period N_2O-emissions kton CO_2eq: -4.8% in 2017 vs 2005 +3.2% non-energetic GHG expressed in CO_2 eq. in 2018 compared to 2005	*58%*	*13%*	*13%*	*8%*	*8%*	N=8	*29%*	*26%*	*26%*	*19%*	N=7
			Argumentations: N_2O emissions from soils need to be reduced by 19% in 2030 compared to 2005, but in 12 years (2005-2017) only 4.8% is reduced yet, so it means that we still need a reduction of 14% in the next 13 years. As N_2O emissions are directly linked to N-input in soils, a major effort will be needed to reach the target. Some techniques to reduce N_2O emissions are known but it is not clear if these techniques will be sufficient to reach the targets.						**Argumentations:** One stakeholders thinks that the policy target is future proof (FECP) but that in practice N_2O emissions from soils will increase in the emission inventory because the manure decree plans a better registration of mineral fertilisers in the near future which will cause a rise in the N_2O emissions. So in practice, the efforts will need to be larger than pointed out in the policy target. N_2O emissions are caused by biological processes and cannot be reduced to zero. We can be ambitious but there are limitations to what technology can do. One stakeholder thinks that the current ambition is quite futureproof because it is difficult to steer soil processes. FECP is purely based on emission inventory rules but there is **very little evidence on actual evolutions in N_2O emissions from soils.** One stakeholder wonders what the **impact of** market evolutions will be, i.e. towards more **proteins for human consumption, natural fibres instead of synthetic clothes/textile.** The stakeholder also wonders if **legume cover crops** should be stimulated and thinks that N-supply from these cover crops should be integrated in fertilisation advice. Budget of A-RD determines its ambitions.					
Avoid peat degradation	**FLS:** Carbon hotspots (peat areas and alluvial forest) are protected by 2050 and disturbed systems are being recovered(**SS**) **A-GM:** protection of permanent grasslands in peat and wetland areas* **A-CC:** Vegetation decision: protection of peat and wetland areas* **BM25**: Protecting global peatlands by stimulating renewable substrates for consumers and horticulture (**SS**)		*39%*	*61%*	*0%*	*0%*	*0%*	N=3	*67%*	*17%*	*0%*	*17%*	N=3
			Argumentations: In Flanders, **peat areas are scattered and mapping of peat areas and other carbon hotspots is not finished yet** (ongoing project). There is some protection in the '*soortenbesluit' (Decision on species, translation of the habitat directive*', but this might miss some peat areas. The **first policy steps are being taken**. The policy instruments to protect peat soils are there, so the protection can start. In **Natura 2000 areas**, **ecological vulnerable grasslands are designated that are located in peat areas**. In these parcels ploughing or converting						**Argumentations:** FLS targets are futureproof. One stakeholder points out that the **FLS policy is well formulated but that it is not quantified and still vague**, so the instruments to achieve the targets are lacking. Peatlands are very vulnerable especially when climate change will increase drought and will lower groundwater tables.					

Soil challenge	Current policy target	Current status of policy targets (when indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Number of answers (N)	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Number of answers (N)
			1	2	3	4	5		1	2	3	4	
			Very large	*Large*	*Halfway*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
			grasslands is prohibited. In the new CAP, there will attention for peat and water rich areas. Carbon hotspots are mainly situated in natural reserves and have **some protection**. Recovery of disturbed systems seems unlikely in many cases. There is a **lack of policy** to protect carbon hotspots. It is not clear how much **peat for substrates** is used in Flanders. There is research to replace peat in substrates by renewables and BM25 will make it easier to use renewable biomass, but there is a lack of policy with binding targets or standards for substrate producers to discourage the use of peat in horticulture.										
Avoid soil erosion	**A-CC**: Less erosion by water with focus on on-site erosion control (**SAS**) **A-RD**: Focus area 4C 1.36% of agricultural land under management contracts to improve soil management and/or prevent soil erosion (maximum to be reached in 2014-2023 period), e.g. grass strips, strategic grasslands, dams, organic farming (**SAS**) **SDE-E**: to lower off-site erosion damage (**SAS**) **SDG30**: Land degradation neutrality by 2030 in Flanders (net no extra degraded land) with soil erosion as indicator (**SAS**)	Max. % of agricultural land under contract for focus area 4C: 0.98% in the 2014-2018 period	*0%*	*6%*	*70%*	*24%*	*0%*	N=8	*13%*	*63%*	*22%*	*3%*	N=8
			Argumentations: There is consensus amongst the stakeholders that there is already **good attention in legislation for soil erosion** in Flanders. In 2016, the measures to be taken by farmers on field parcels with (very) high erosion risks got stricter (A-CC). So, many steps are taken but the **adoption rate of measures such as non-inversion tillage could still be increased**. Some farmers still do not know what measures they have to take on erosion sensitive field parcels, so there is room for improvement. Apart from on-site measures, in some situations farmers can also choose for off-site measures such as grass buffer strips (A-CC) and also SDE-E focuses on off-site erosion effects, but this still causes erosion on the field parcel itself. One stakeholder points out that on-farm checks for A-CC are minimal and that **awareness raising and support** is needed because legislation is complex. This stakeholder advises to register measures taken through cross-compliance (parcel) registrations which would be an advantage both for the farmers (automatic check) themselves and for on-farm checks. The adoption degree of voluntary measures could still increase. The target for A-RD was nearly met. Another stakeholders points out that it is not clear how fast the % of contracts can increase as older contracts may not be renewed. **SDE-E does not have a clear target** and off-site damage still occurs. SDG30: we are not there yet to reach land degradation neutrality.							**Argumentations:** Several stakeholders think that the way erosion is tackled in Flanders is the right one but that some **fine tuning in the future will still be needed** to increase the effectivity. It remains a work in progress. Several stakeholders point out that **targets are not quantified yet**. For instance there is no definition of the maximum erosion risk that is allowed to be land degradation neutral (SDG30). Improved soil management and erosion control should be common practice on all agricultural land. We should reach no off-site damage to water, nature or infrastructure as a result of mainly soil protection in combination with off-site measures for extreme events. One stakeholder thinks that extreme weather events will in the future always cause some risks for erosion and that this cannot be avoided; so the stakeholder thinks that the current legislation is futureproof. Several other stakeholder agree that **climate change** will lead to more erosive rainfall events and thus erosion, but one stakeholder thinks that more measures are therefore needed to protect soils. Three stakeholders state that also **wind erosion** should be targeted. It is expected that wind erosion will become a					

Soil challenge	Current policy target	Current status of policy targets (when indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Number of answers (N)	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Number of answers (N)
			1	2	3	4	5		1	2	3	4	
			Very large	*Large*	*Halfway*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
									larger problem in the future on sandy soils due to climate change leading to drier periods and heavier winds. More diverse alternative contracts or approach methods could give equal effective results and simultaneously improve wildlife.				
Avoid soil sealing	**SDG30**: Land degradation neutrality by 2030 in Flanders (net no extra degraded land) – with soil sealing as one of 3 indicators (**SS**) **BRV**: % sealed surface -20% by 2050 compared to 2015 in land use categories agriculture, nature and Forest (**SS**) Target of net zero land take by 2040* (**SS**)	Soil sealing (area artificial soil covering/total area): 16% in 2015 (**SS**) Settlements is 33%; land take rate: ca 6ha/day in 2016*	*50%*	*44%*	*6%*	*0%*	*0%*	N=8	*16%*	*28%*	*25%*	*31%*	N=8
			Argumentations: Several stakeholders point out that soil is sealed at an increasing rate in Flanders (7.6 ha/day) and that **net decreasing is thus not started yet**. One stakeholder thinks that current de-sealing initiatives are not more than a drop in the ocean. Although there are figures on the regional scale, there are **little to (no?) data on the sealing problem of agricultural soils**. One of the stakeholders think it is mainly a problem of settlements. Time and time again we **fail to implement any specific tools to establish the ambition**, e.g. '*betonstop*' becoming '*bouwshift*'.						**Argumentations:** Several stakeholders point out that there are some **problems with the BRV target** that the sealed surface in the categories agriculture, nature and forest should decrease with 20%. One of them is land use change. If 20% of sealed agricultural land becomes industry, then the target is reached but in practice nothing has changed. Another stakeholder says that the target is futureproof but that the **instruments how to reach the targets are not implemented yet**. Another stakeholder expresses his concerns about urban and industrial areas. What about the huge areas that are reserved for urban development? Do they fall outside the scope of the target? In addition, the open space is also challenged by so-called "**virtual farmland": land with an agricultural destination, used by non-agricultural users**. The targets for desealing do not include **soil care afterwards**. Desealed space/surface ('*grond*') is not equal to 'soil' ('*bodem*'). One of the stakeholders stresses that due to climate change, the importance of soils and soil ecosystem service will increase. Therefore it is important to avoid soil sealing and to encourage desealing of soils.					
Avoid salinisation			*0%*	*0%*	*0%*	*0%*	*100%*	N=1	*0%*	*0%*	*0%*	*100%*	N=4
			Argumentations: One stakeholder has scored 'no gap' because there is **no policy** at the moment on salinization. Other stakeholders did not score because of this reason. There is only some legislation on groundwater capitation and the use of saline water but not on soil salinization itself.						**Argumentations:** The stakeholders that scored believe that salinization **will become a more important problem** in Flanders due to **climate change**. In the past salinization was not really an issue because of an excess of precipitation but drought became an important issue in recent years, so it is important to consider.				

Soil challenge	Current policy target	Current status of policy targets (when indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Number of answers (N)	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Number of answers (N)
			1	2	3	4	5		1	2	3	4	
			Very large	*Large*	*Halfway*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
Avoid acidification	**A-CC**: soil carbon content (% C) of field parcels above minimum threshold, pH in optimal zone (**SAS**) **A-CC**: When %C>1.7% +pH is optimal, erosion sensitivity class of the field parcel is lowered (**SAS**)		*0%*	*42%*	*33%*	*17%*	*8%*	N=6	*50%*	*14%*	*7%*	*29%*	N=7
			Argumentations: Farmers are obliged to have a number of soil analysis on %C and pH, but results are not considered during the on-farm checks (A-CC). **Seasonal rent** is often a problem to maintain soil fertility. Many agricultural soils do not have a pH in the optimal zone (*this can be deducted from analysis results from the Belgian soil service for farmers, but there is **no monitoring network** in place*).						**Argumentations:** Two stakeholders have given a score 'very far' from futureproof. They argue that it is getting worse with soil pH (experience in practice) or that there are no clear targets yet and it is not clear what the way forward is. Other stakeholders have scored the targets as being futureproof. They argue that the target is already that soils should be in the optimal zone for pH. Other stakeholders have scored in between. They say that the target is futureproof, but that the **implementation and control is lacking**. They also point out that the pH can also be too high.				
Avoid contamination	**SDG30**: Land degradation neutrality by 2030 in Flanders (net no extra degraded land) with soil contamination as indicator (**SS**) **SUP**: Regulating the sustainable use of pesticides, implicitly aiming to reduce the impact on soil, soil contamination and water (**SS**); To ensure that type (licensed), amount and concentrations of pesticides used in agriculture is in line with guidelines for good agricultural practices (**SAS**) **BD**: Prevention and remediation of soil contamination and clean-up historical contamination by 2036 (**SS**) Regulates re-use of excavated soil materials in order to reduce impact on the environment including soils (**SS**)* **MD**: Regulates use of waste and materials (including sewage sludge) as fertilizer or soil improving substances in order to reduce impact on the environment including soils (**NS**)		*0%*	*0%*	*70%*	*13%*	*17%*	N=6	*50%*	*50%*	*0%*	*0%*	N=4
			Argumentations: One stakeholder has the opinion that SUP is not relevant. It is argued that pesticides are potentially a source of contamination for water but under the current legislation not for soil. Pesticides would, when applied with current good practices, no be a threat for soils. Another stakeholder also thinks that there is **no gap because regulations are already strict**. Other stakeholders think we are only halfway. Two of them point out that there should be **more attention to diffuse contamination** (e.g., pesticides, heavy metals from manures, micro plastics, antibiotics). One stakeholder explains that the regulatory framework on excavated soil is established (BD) and a regulatory framework on diffuse pollution is in preparation, so the establishment of legislation frameworks is halfway (for all soils, not only for agricultural soils). Legislation on diffuse contamination will include new parameters such as pesticides.						**Argumentations:** The two stakeholders that think contamination of agricultural soils is no problem because legislation is already strict, also think that policy targets are futureproof. Two other stakeholders think that policy targets are almost futureproof. One of them argues that targets are there but the regulatory framework on diffuse pollution should be ready and already being implemented by 2050.				

Soil challenge	Current policy target	Current status of policy targets (when indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Number of answers (N)	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Number of answers (N)
			1	2	3	4	5		1	2	3	4	
			Very large	*Large*	*Halfway*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
Optimal soil structure	**A-RD**: No targets; only investment support for low pressure tyres and tyre air pressure system (**SAS**) **A-CC**: soil carbon content (% C) of field parcels above minimum threshold, pH in optimal zone (**SAS**)*		*40%*	*40%*	*20%*	*0%*	*0%*	N=5	*0%*	*0%*	*50%*	*50%*	N=6
			Argumentations: There is **no target on soil structure yet**, but the investment support shows the importance of soil structure and efforts are being made (scored halfway). Only early adopters and contractors work with air pressure systems and low pressure tyres (A-RD) (scored large gap). Measures for remediation of soil structure damage are often a side effect. Think of cover crops. This is a greening measures and most farmers comply with greening by sowing cover crops (scored large gap). **We need policy for prevention and remediation of soil compaction**. This is crucial for infiltration and combatting drought, water excess and erosion (scored very large gap). Because there is investment support, policy makers make clear that prevention of soil compaction is important but only few tractors have tyre pressure systems and much land is still trafficked under bad conditions. Moreover, investment support is not available for contractors although they are equipped with the heaviest machinery and quite often enter the field in bad conditions (scored very large).						**Argumentations:** Stakeholders think that policy targets are far to very far from futureproof because there are no real targets yet. There is only investment support (A-RD) and side effects of other policies. An optimal soil structure is not only to be reached by low tyre pressure. It is an important soil challenge because problems such as droughts, flooding and erosion will increase due to **climate change** in the future and soil compaction hampers water uptake during dry periods and water storage in the soil during wet periods. An optimal soil structure is also very important to achieve sustainable cultivation with less fertilisers. So soil compaction should be avoided as much as possible. However, soil structure is a difficult soil challenge to formulate good targets.				
Enhance soil biodiversity	**A-GM**: Crop diversification for a healthy soil. Farmers need to grow 2 or 3 different crop types depending on their cultivated area (**SAS**)		*14%*	*29%*	*0%*	*29%*	*29%*	N=7	*29%*	*14%*	*29%*	*29%*	N=7
			Argumentations: The stakeholders that scored small or no gap (N=4) refer to A-GM and argue that crop diversification is almost always applied in practice as it is compulsory for cross compliance. Other stakeholders think the gap is large to very large (N=3). These stakeholders argue that crop diversification is good for soil biodiversity but probably not the best instrument, crop rotation would be better. Arable land in Flanders is still dominated by few main crops, although the area of cover crops has increased. Other stakeholder add that more measures are needed for a healthy soil life, such as sufficient soil carbon, minimum tillage, less pesticides, wider crop rotations, more high residue crops such as cereals and cover crops. We still know very little on soil biodiversity and how to enhance it to a desired level. There a no good policy instruments at the moment to enhance biodiversity.						**Argumentations:** One stakeholder that scored almost futureproof thinks that 2 crops should be sufficient on dairy farms when they have a large share of grassland. Stakeholders that scored far to very far from being futureproof say that the importance of soil biodiversity is underestimated. Soil biodiversity is also important during periods of drought and weather extremes and for disease suppression. There are **still many unknowns** when it comes to soil biodiversity (**status, evolution, role**). These **insights are needed to develop proper legislation and targets**. One stakeholder also wonders if we should strive to enhance soil biodiversity in general or if we should stimulate specific functional groups? It is questioned whether crop diversification is sufficient.				

Soil challenge	Current policy target	Current status of policy targets (when indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Number of answers (N)	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Number of answers (N)
			1	2	3	4	5		1	2	3	4	
			Very large	*Large*	*Halfway*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
Enhance soil nutrient retention/use efficiency	**ND**: Threshold values for residual nitrate at the field parcel level between 1/10 and 15/11 as indicator for the nitrate leaching risk in winter; threshold values are depending on crop type, soil texture and water quality area (60-90 kg nitrate-N/ha from 0-90 cm) (**SAS**) **ND**: To steer P availability in the soil towards a target zone for soil fertility and limited environmental risks (**SAS**)	Weighted average residual nitrate (kg nitrate-N/ha in the 0-90 cm layer): 2004: 111 kg nitrate-N/ha – 2018: 89 kg nitrate-N/ha >70% of agricultural field parcels has available P content above the target of 18 mg P/100 g air dry soil in 2019 (note: this does not include parcels without analysis))	*0%*	*50%*	*29%*	*7%*	*14%*	N=7	*36%*	*43%*	*21%*	*0%*	N=7
			Argumentations: One stakeholder points out that regarding the target of 18 mg P/100 g air dry soil, we should make a distinction between grasslands and arable land. '*This target is indeed valid for arable land, the target for grasslands is 25 mg P/100g air dry soil.*' One stakeholder beliefs there is no gap because there is already much attention for nutrient retention/use efficiency in Flanders. Others have scored 'halfway' or 'large' because despite the efforts being made, **residual nitrate and phosphate contents in soils are still too high** and in some areas targets are not reached yet. In the past years results did not improve or even got worse. Could that be a consequence of climate change? P is a very slow responding parameter but legislation is in place. One stakeholder says that for some crop types it is feasible to reach targets, for other crop types this is economically not feasible.							**Argumentations:** Most stakeholder think that current targets are almost futureproof or futureproof. One stakeholders think that overall targets are ok, but more specific targets are specified per manure action plans and perhaps we should develop a more long term vision. One stakeholder wonders if targets/legislation on nitrates is futureproof when considering climate change.				
Enhance water storage capacity	**PN-E**: It is investigated how to make soils and soil use more climate proof with special attention to drought and excess of water (**SS**) **PN-A**: focus on increasing water holding capacity of soils (**SAS**)		*17%*	*58%*	*25%*	*0%*	*0%*	N=6	*0%*	*0%*	*17%*	*83%*	N=6
			Argumentations: Two stakeholders point out that enhancing water storage capacity is strongly **linked with other soil challenges** such as soil carbon and soil structure. Soil water capacity does not have a target itself. The link with other soil challenges should further be investigated. One stakeholder argues that there is already much attention (a.o. in demonstration trials) for the importance of soil carbon. Another stakeholder thinks **knowledge on increasing water holding capacity in the farming practice and making soils more drought resistant needs to be enhanced**. This stakeholder also thinks that it is quite well known what farmers can do to make sure excess water infiltrates and does not lead to erosion.							**Argumentations:** There is consensus amongst stakeholders that the policy targets are far to very far from being futureproof. There are **no clear quantified targets** yet, although water retention will only gain more importance in the future due to **climate change** (drought and excess water). One stakeholder points out that it is very difficult **to formulate policy targets and to monitor these targets**. Another stakeholder thinks integrated policies are important. One stakeholder thinks **more strategies for water retention in farmland should be developed**. Farmers should actively contribute and set examples.				
Land degradation in general	**SDG30:** Land degradation neutrality by 2030 in Flanders (net no extra degraded land) (**SS**) **V50**: ; land degradation is stopped by 2050	Indicators used: soil sealing 16% in 2015, polluted sites, soil erosion	*50%*	*33%*	*0%*	*17%*	*0%*	N=6	*17%*	*17%*	*33%*	*33%*	N=6
			Argumentations: Most stakeholders think that the gap is large to very large, especially for soil sealing. One stakeholder says there is a huge gap between the discourse of preventing soil sealing and the development of actual policies that address soil sealing adequately. Soil erosion is						**Argumentations:** The target to reach land degradation neutrality by 2030 might be futureproof **but targets should become more quantified and more clearly defined and monitored.**				

Soil challenge	Current policy target	Current status of policy targets (when indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Number of answers (N)	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Number of answers (N)
			1	2	3	4	5		1	2	3	4	
			Very large	*Large*	*Halfway*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
			already decreased but not stopped and soil compaction remains a problem.										

* Added in the validation phase by stakeholders who completed the questionnaire (and thus not included in the questionnaire)

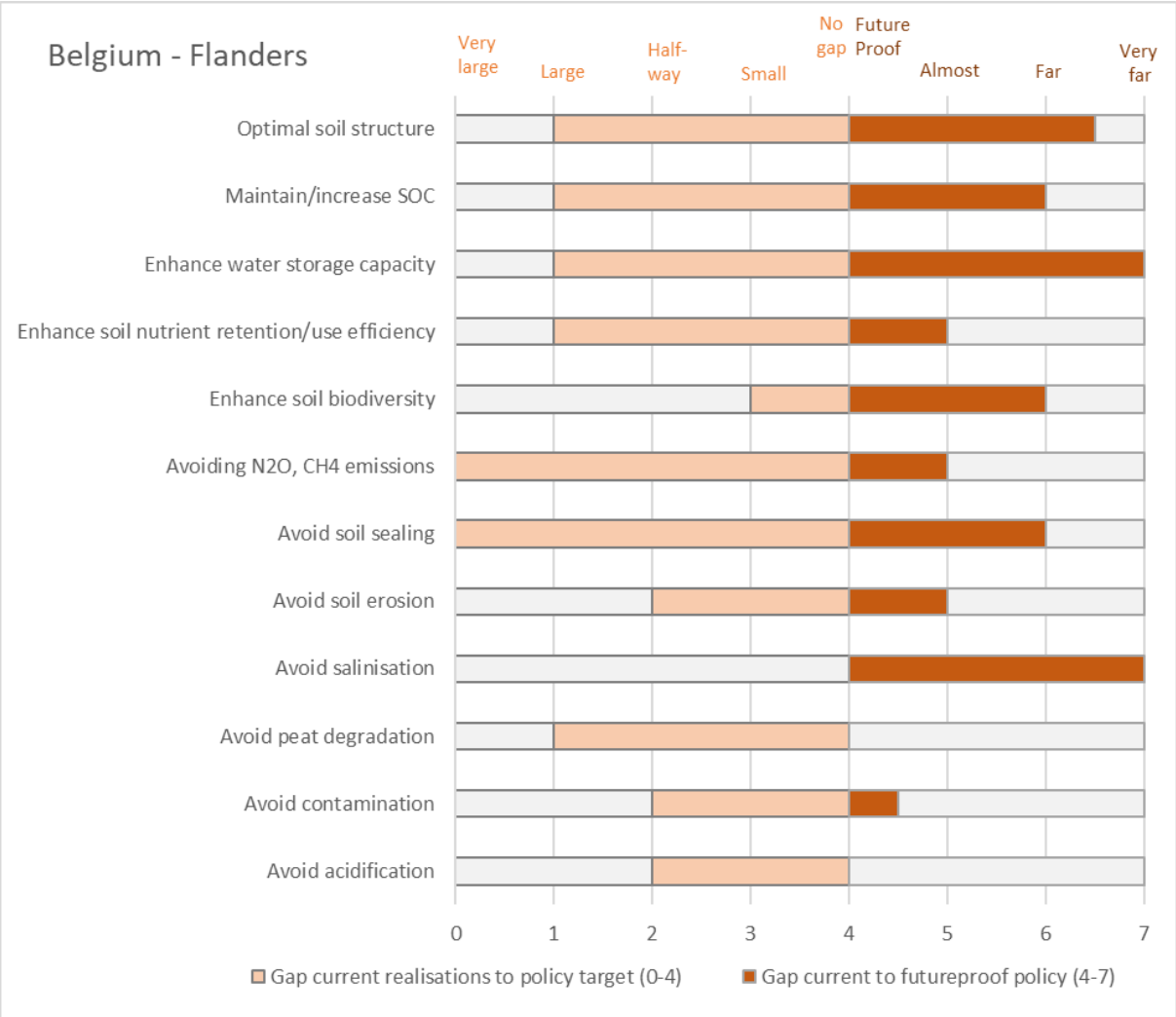


Figure 2 *Overview of stakeholder scores for the gap between current realisations and policy targets and the gap between current and future proof policies. The values shown are median values.*

Figure 2 provides an overview of the median stakeholder scores per soil challenge. For most soil challenges, the stakeholders indicated that the **gap between current policy targets and realisations** is large to very large. For soil erosion, soil contamination and acidification, there was consensus that realisations are half way the targets. Stakeholders argued that there is already much attention for **soil erosion** in legislation (a.o. CAP-GAECs) and steps have been taken to reduce erosion but soil erosion is still occurring and the adoption rate of erosion mitigating measures could still increase. Regarding **contamination**, some stakeholders think that the legislation on pesticides is already very strict, so there should be no problems, but others think there are still some gaps e.g. on diffuse contamination. For soil **salinization** it was identified that there was no gap because there are no policy targets in place yet. Votes for **soil biodiversity** were very divided. Stakeholders that scored small to no gap between realisations and policy targets look at the greening measures and argue that farmers already comply. Others think that greening measures are not sufficient to enhance soil biodiversity.

Policy targets on **peat degradation, soil erosion, acidification, soil contamination and enhanced nutrient retention/use efficiency** are regarded to be **(almost) futureproof**, while policy targets for **soil**

organic carbon, salinization, soil structure and enhancing water storage capacity are regarded to be (very) far from being future proof. For non-CO_2 greenhouse gas emissions, soil sealing, soil biodiversity and land degradation in general stakeholders disagree.

Overall, gaps between current realisations and what would be futureproof targets are large for all soil challenges and most progress has already been made for soil erosion and soil contamination although in the future also wind erosion and diffuse contamination should be considered.

4.2 Soil management practices to achieve the aspirational goals

4.2.1 Soil management practices as suggested by the stakeholders

After setting the aspirational goals, the stakeholders were asked to select the soil management practices that are most appropriate to achieve the aspirational goal for the different soil challenges. Table 6 provides an overview of the proportion (%) of stakeholder votes that a management practice got per soil challenge. Figure 3 shows the relative share of the main land categories to which the practices belong over all challenges and Figure 4 does the same but per soil challenge.

Apart from selecting the most suitable management practices per soil challenge, the **stakeholders** were also asked to add **clarifications and comments** related to their choices or general remarks. These are summarized in Box 1.

When looking at the different land management categories, these are the most important conclusions:

- Practices belonging to **organic matter and nutrient management** are most mentioned by stakeholders (25%) and are regarded to be mainly important for avoiding acidification, avoiding N_2O/CH_4 emissions and enhancing nutrient use/use efficiency. Most promising techniques for a range of soil challenges are reduced/more precise mineral fertiliser application, fertiliser plans/advice, appropriate compost and farmyard manure application, better manure storage and treatment.
- **Crops and crop rotations** (21%) are especially regarded important for maintaining/increasing SOC and to avoid soil erosion. Overall, cover crops/catch crops and more grassland are regarded beneficial for multiple soil challenges. Other important crops are cereals, legume crops and intercropping/multiple cropping and perennial crops. Several stakeholders also mentioned that crop rotations could be adjusted to deal with several soil challenges (Box 1).
- **Adjusting tillage and traffic practices** (18%) is especially important for an optimal soil structure and to reduce erosion, but also to enhance soil water holding capacity and soil biodiversity. Different forms of non-inversion/reduced/minimum tillage are believed to decrease peat degradation and soil erosion and to enhance soil biodiversity. Controlled traffic farming, less heavy machines and adjusting tyre types and pressures are especially beneficial for a good soil structure.
- **Agricultural systems** (17%) were regarded especially important to enhance soil biodiversity and avoid soil contamination. Precision agriculture, conservation agriculture and agro-ecological farming were most mentioned systems.
- **Water management** (13%) is believed to be important for avoiding soil salinisation, avoiding peat degradation and to enhance water storage capacity. To enhance water storing capacity we should learn from more arid countries how to reduced moisture loss, eg by mulching (Box 1).

- **Mechanical weeding and more precise herbicide application** (Crop protection) is especially mentioned to avoid soil contamination.
- **Buffer strips and landscape elements** were not so frequently mentioned except for soil erosion.

In general some stakeholders point out that a **systems thinking** is important and that measures should be combined (Box 1).

Table 6: *Ranking of soil management practices to achieve aspirational goals as indicated by stakeholders. Numbers are the percentage of votes (%) a management practice got for a given soil challenge. Grey cells are main land management categories and the percentages are the sum of percentages of the management practices belonging to that category. Dark green: >=5%, light green: between 1 and 5%. Note that the interpretations stakeholders have given to soil sealing is different from the definition used in paragraph 3.*

	Overall	Maintain/increase SOC	N2O/CH4 emissions	Peat degradation	Avoid soil erosion	Avoid soil sealing	Avoid salinisation	Avoid acidification	Avoid contamination	Optimal soil structure	Enhance soil biodiversity	Enhance nutrient use/use efficiency	Enhance water storage capacity
Number of questionnaires with answers	10	8	8	5	8	4	7	5	8	8	8	9	9
Crops/rotations	**20**	**37**	**13**	**18**	**38**	**27**	**7**	**10**	**7**	**27**	**15**	**25**	**22**
More cereals	1,9	5,6	1,4	0,0	2,0	0,0	0,0	0,0	0,0	6,8	0,0	0,9	5,7
More legume crops	1,6	0,0	5,7	0,0	0,0	6,3	0,0	3,3	0,0	0,0	0,0	3,7	0,0
More grassland	4,5	11,5	1,4	10,0	12,4	0,0	7,1	3,3	0,0	0,0	1,1	3,5	3,4
Intercropping/multiple cropping	1,6	0,0	0,0	0,0	2,0	6,3	0,0	0,0	5,4	2,6	1,1	0,0	1,4
Cover/catch crops	6,4	8,4	1,4	0,0	10,8	14,6	0,0	3,3	1,3	14,6	6,4	15,5	0,9
Perennial crops	1,2	1,2	0,0	3,3	6,2	0,0	0,0	0,0	0,0	0,0	1,4	0,0	2,3
Permanent grazing	0,1	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Rotational grazing	0,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,6	1,1	0,9	1,4
Zero grazing	0,3	0,0	3,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other: keep area grassland (*regional level*)	0,3	3,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other: permanent grasslands to remain at same place	0,1	1,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other: reasoned crop rotation	0,3	3,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other: crop rotation	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	4,2	0,0	0,0
Other: crop rotation that impoves soil structure and carbon content	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,7
Other: reasoned crop rotation considering erosion sensitivity of crops	0,3	0,0	0,0	0,0	4,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other: maximised soil cover to avoid sealing, to improve infiltration and decrease evaporation	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,7
Other: paludiculture crops	0,4	0,0	0,0	5,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other: crops with early harvest	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,0	0,0	0,0	0,0
Other	0,1	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Tillage and traffic	**18**	**14**	**17**	**22**	**31**	**21**	**0**	**0**	**0**	**51**	**22**	**12**	**25**
No till	3,1	4,4	2,6	15,0	3,2	0,0	0,0	0,0	0,0	3,1	3,8	1,2	3,4
Non-inversion/reduced tillage	3,4	3,5	2,6	3,3	12,9	0,0	0,0	0,0	0,0	4,2	8,6	1,2	4,6
Non-inversion/minimum tillage	1,3	0,8	1,2	3,3	2,0	0,0	0,0	0,0	0,0	3,1	3,8	0,0	1,1
Non inversion tillage	3,5	4,4	1,4	0,0	10,4	8,3	0,0	0,0	0,0	5,2	4,2	3,7	4,6
Deep ploughing	1,0	0,0	0,0	0,0	0,0	12,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Contour plouging	0,6	0,8	0,0	0,0	2,0	0,0	0,0	0,0	0,0	1,6	0,0	1,2	1,4
Terrace farming	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Controlled traffic farming	2,2	0,0	5,1	0,0	0,0	0,0	0,0	0,0	0,0	12,5	1,1	0,9	6,4
Other: avoid soil compaction	0,9	0,0	3,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,7	3,7
Other: Low tyre pressure AND trafficking with heavy machinery under good soil moisture conditions AND measures that avoid heavy machine loads	1,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	12,5	0,0	0,0	0,0
Other: low pressure tyres and adjusted pressure	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,1	0,0	0,0	0,0
Other: less heavy machinery	0,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,2	0,0	0,0	0,0

Table 6: *continued*

	Overall	Maintain/increase SOC	N2O/CH4 emissions	Peat degradation	Avoid soil erosion	Avoid soil sealing	Avoid salinisation	Avoid acidification	Avoid contamination	Optimal soil structure	Enhance soil biodiversity	Enhance nutrient use/use efficiency	Enhance water storage capacity
Organic matter/nutrient management	**25**	**27**	**60**	**7**	**3**	**8**	**17**	**83**	**13**	**7**	**21**	**46**	**15**
Reduced/more precise mineral fertiliser application	6,0	0,0	16,6	0,0	0,0	0,0	4,8	20,0	12,5	0,0	1,1	17,0	0,0
Appropriate compost application	4,1	8,9	0,0	0,0	0,7	8,3	0,0	6,7	0,0	2,6	11,1	3,1	8,1
Appropriate farmyard manure application	2,7	2,2	12,3	0,0	0,7	0,0	0,0	6,7	0,0	1,6	5,8	2,2	1,1
Biochar application	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Incorporation of crop residues	1,2	5,3	0,0	0,0	1,0	0,0	0,0	0,0	0,0	2,6	2,7	2,2	1,1
Fertilisation plan/advice	5,3	0,7	8,5	0,0	0,7	0,0	11,9	28,3	0,0	0,0	0,0	13,3	0,0
Better manure storage	1,1	0,0	13,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Manure treatment	1,1	0,7	8,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,4	0,9
Valorisation of waste streams	0,2	1,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,2	0,0
Enhanced weathering	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other: all fertilizatin with animal manure	0,3	3,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other: (appropriate) liming	1,8	0,0	0,0	0,0	0,0	0,0	0,0	21,7	0,0	0,0	0,0	0,0	0,0
Other: smart use of carbon rich products (eg manure, compost, harvest residues)	0,3	3,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other: improving soil organic carbon	0,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	3,7	3,7
Other: no peat in soil substrates	0,6	0,0	0,0	6,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Crop protection	**4**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**49**	**0**	**2**	**0**	**0**
Mechanical weeding	2,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	31,5	0,0	1,1	0,0	0,0
Precision herbicide application	1,1	0,7	0,0	0,0	1,3	0,0	0,0	0,0	9,6	0,0	1,1	0,0	0,0
Other: classical IPM techniques	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	4,2	0,0	0,0	0,0	0,0
Other: minimal use of harmful crop protection productes (other than herbicides)	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	4,2	0,0	0,0	0,0	0,0
Other	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Water management	**13**	**2**	**0**	**53**	**3**	**0**	**64**	**0**	**0**	**3**	**1**	**6**	**20**
Irrigation	2,2	0,0	0,0	0,0	0,0	0,0	21,4	0,0	0,0	0,0	0,0	4,6	0,0
Subsurface drainage	1,0	0,0	0,0	0,0	2,0	0,0	4,8	0,0	0,0	1,0	0,0	0,9	3,7
Increasing water tables	5,0	2,2	0,0	36,7	1,3	0,0	7,1	0,0	0,0	1,6	1,1	0,0	10,0
Allow flooding	1,4	0,0	0,0	10,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	6,4
Other: reverse drainage	0,4	0,0	0,0	0,0	0,0	0,0	4,8	0,0	0,0	0,0	0,0	0,0	0,0
Other: targeted water management	1,2	0,0	0,0	0,0	0,0	0,0	14,3	0,0	0,0	0,0	0,0	0,0	0,0
Other: no drainage ground water extraction	0,6	0,0	0,0	6,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other: no ground water use during drought	0,6	0,0	0,0	0,0	0,0	0,0	7,1	0,0	0,0	0,0	0,0	0,0	0,0
Other: irrigation water quality rules	0,4	0,0	0,0	0,0	0,0	0,0	4,8	0,0	0,0	0,0	0,0	0,0	0,0
Buffer strips/small landscape elements	**2**	**4**	**0**	**0**	**18**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**0**
Grass buffer strips	0,9	1,6	0,0	0,0	7,9	0,0	0,0	0,0	1,3	0,0	0,0	0,0	0,0
Other buffer strips	0,7	0,8	0,0	0,0	6,4	0,0	0,0	0,0	1,3	0,0	0,0	0,0	0,0
Hedges	0,5	1,6	0,0	0,0	3,5	0,0	0,0	0,0	1,3	0,0	0,0	0,0	0,0
Agricultural systems	**17**	**16**	**10**	**0**	**6**	**44**	**12**	**7**	**28**	**14**	**39**	**12**	**17**
Organic farming	1,5	0,7	0,0	0,0	0,0	0,0	0,0	0,0	9,6	0,0	7,6	0,0	0,0
Agro-ecological farming	2,8	1,4	0,0	0,0	0,7	0,0	0,0	0,0	12,7	1,0	15,9	0,9	0,9
Precision agriculture	3,6	0,7	7,6	0,0	0,0	0,0	11,9	3,3	5,4	1,0	4,3	8,3	0,9
Agroforestry	1,7	4,2	2,6	0,0	0,7	6,3	0,0	0,0	0,0	0,0	1,6	2,5	2,5
Conservation agriculture	3,2	8,1	0,0	0,0	4,9	0,0	0,0	3,3	0,0	5,2	9,5	0,0	7,6
Other: 1. use of less heave and smaller machinery or low pressure tyres; 2. better follow-up of seasonal rent	2,0	0,0	0,0	0,0	0,0	12,5	0,0	0,0	0,0	6,3	0,0	0,0	5,6
Other: traditional system, but no ploughing when/where conditions allow this	0,1	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other: de-sealing (*removing impermeable surfaces such as concrete*)	2,1	0,0	0,0	0,0	0,0	25,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

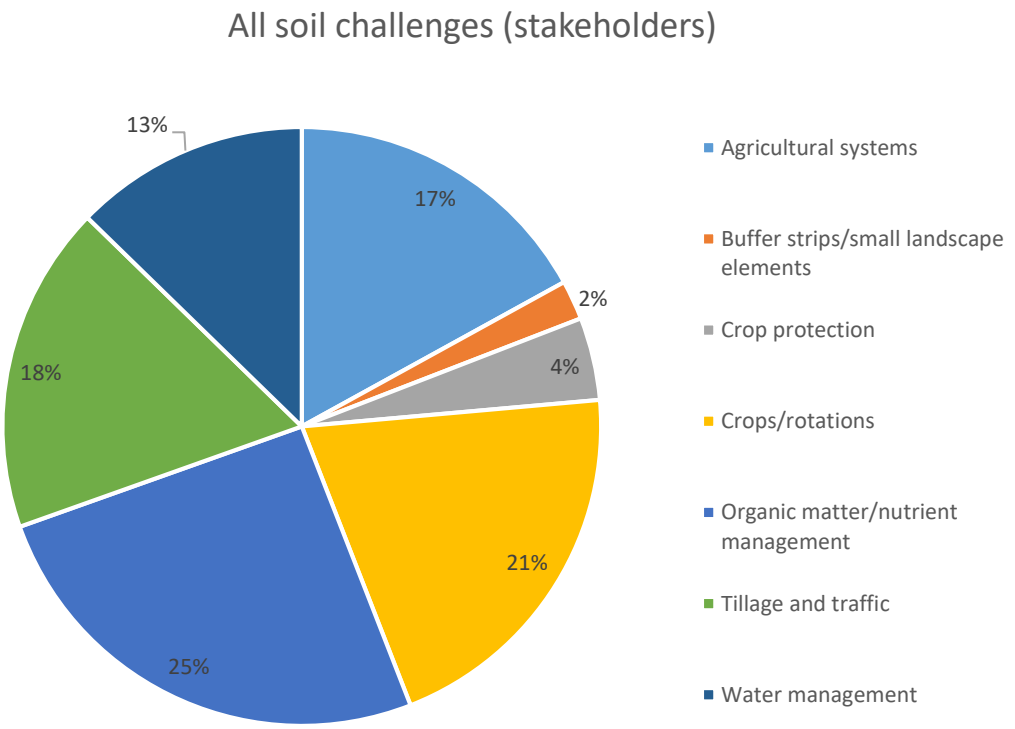


Figure 3: *Relative share of land management categories prioritized by stakeholders in Flanders. Data are summarized across all soil challenges*.

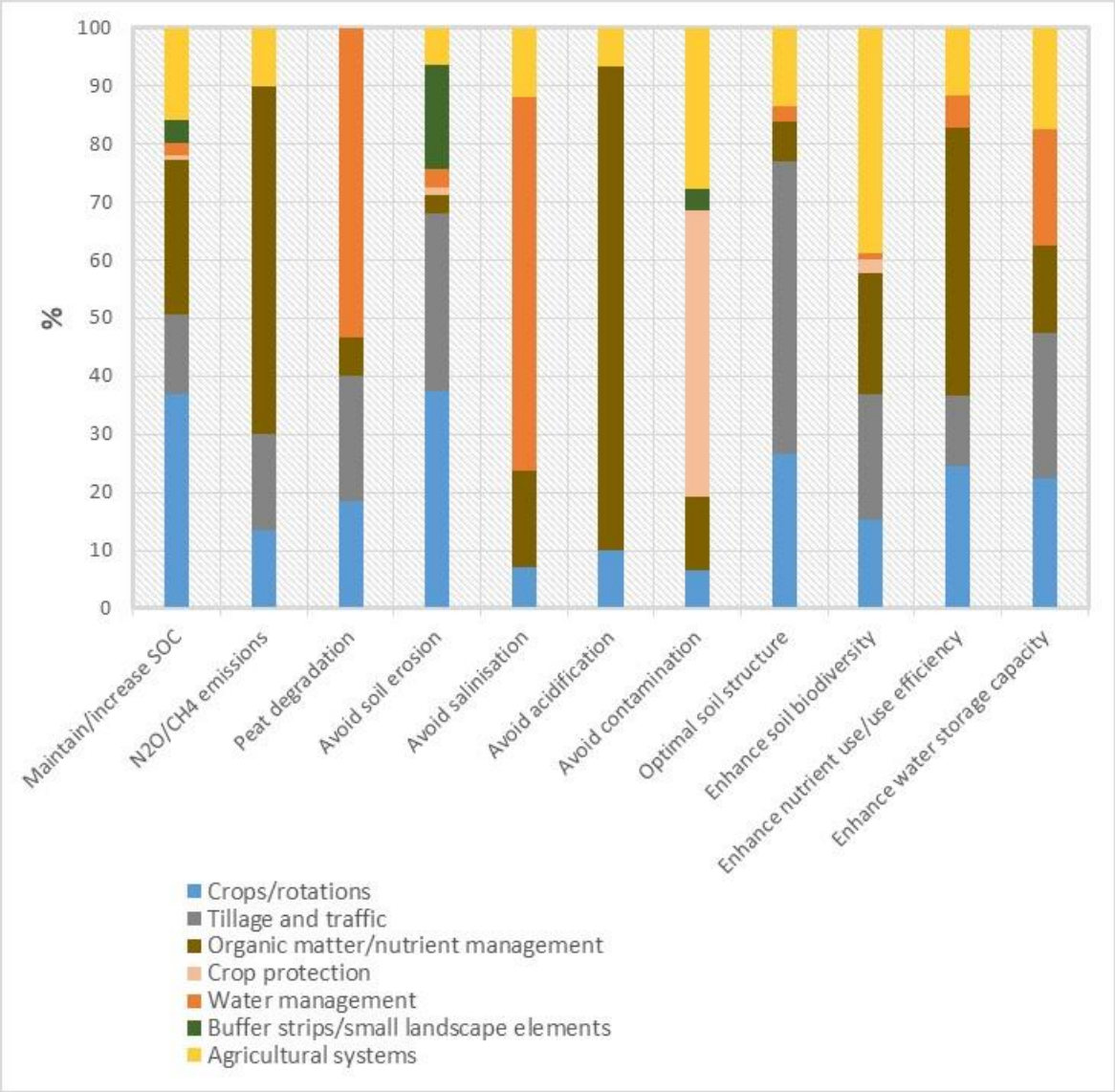


Figure 4: *Relative share of management practices chosen in land each management category per soil challenge. Note that soil sealing is not displayed here as some of the stakeholders had interpreted this different from the definition used in chapter 3*.

Box 1: *Comments and clarifications of stakeholders to Table 6*

- Apart from the practices shown in Table 6, it was mentioned that **seasonal rent** has a detrimental impact on soil quality. The impact of seasonal rent might even be more important than the practices mentioned in Table 6 as farmers are much more motivated to keep their soils in good conditions when they own the land or use it under long term rent. There are currently discussions going on how to overcome this negative impact, but solutions are hard to find. A soil passport (as currently being developed) could provide a solution.
- It was not always easy to choose between agricultural systems and individual measures because these individual measures are often part of the system. In the category '**agricultural systems**' only 'alternative' systems are mentioned but an improved traditional system should also belong here. Think of not-ploughing when possible (so not necessarily every year but depending on the conditions) or the application of integrated pest management

- One measure or one group of measures (eg. tillage, crop protection) is usually not sufficient to improve soil quality or decrease the risk for soil degradation (unless perhaps precision farming). SOC is presumably the most important driver for a good soil and a **combination of measures** is needed. Several parameters of soil quality also interact with each other. The amelioration of one parameter is often also positive for other parameters (and vice versa). Agriculture has an impact on soil quality parameters but also intrinsic soil parameters and environmental conditions (climate, soil texture, soil type) play an important role. The consequence is that investments in soil quality should be weighed against the potential for improvement and the time to reach this result ("trajectory") and this is a consideration that should be taken field parcel by field parcel; management practices should be chosen field parcel by field parcel. A **systems thinking** in function of soil quality and the long term impact on the environment of that field parcel is essential. This systems thinking involves the right crop rotation and other soil management practices, the evolution of yield potential and resilience against climate change and weather extremes. Important to consider is the balance between valorisation of a field parcel and the production methods, i.e. short-term profits but detrimental for the environment versus often slower but more sustainable exploitation of soils.
- **Soil organic carbon** increase could be stimulated by stimulating chains for crops that are deep rooting, have large root systems and leave a large mass of biomass residues with stable C content on the field. It could also be stimulated by encouraging longer growing periods of cover crops (and thus main crops that are harvested early in the season). Periods with bare field should be avoided. Biomass and root mass could be increased by having multiple crops on the field at the same time. Biomass residues should be optimally used for increasing SOC on farmers' fields as is outlined in the biomass action plan.
- **N_2O emissions** could be more avoided when crops that only need low nutrient input would be stimulated. Thus stimulating low-nutrient input chains.
- We should learn from more arid countries what practices can help to **avoid moisture loss** from soils when drought problems become increasingly important. Mulching could be one of these practices, that are moreover helpful in avoiding soil erosion
- **Soil sealing** was misunderstood by most stakeholders who completed the table. They were rather thinking of soil compaction.
- **Soil contamination** can be avoided by strongly reducing harmful persistent toxic substances on the soil such as pesticides and antibiotics.
- **Combining multiple data sources** such as soil scans, tractor, UAV and satellite remote sensing data and weather data should allow to better detect problems with soil quality so that targeted solutions could be implemented to improve soils and crop yield potential.
- The question was to select measures that are most promising to achieve the aspirational goals, but one stakeholder pointed out that the table could be interpreted in several manners. Does it mean measures with highest effect on the soil challenge (on a ha basis) or should the potential degree of adoption and feasible area also taken into account? This stakeholder has chosen for the measures with the highest theoretical impact regardless of the feasibility for implementation.

4.2.2 Soil management practices: a comparison between policy and stakeholder views

When comparing the soil related management practices listed in policy documents (Table 4) and mentioned by stakeholders (Table 6), the following conclusions could be drawn.

- The management practices listed in policy documents belong for 60% to the categories organic matter/nutrient management and crops/rotations (Figure 1). These were also the most important categories for the stakeholders but they accounted only for 46 % (Figure 3). The third main category was buffer strips/landscape elements in policy, while this was only mentioned few times by stakeholders. The stakeholders paid more attention to the potential of practices in the categories tillage/traffic, agricultural systems and water management.
- In the category **crops/rotations** the importance of catch crops/cover crops and grasslands for various soil challenges was obvious both in policy documents and for stakeholders. Also more cereals, legume crops and perennial crops were mentioned by both. Stakeholders paid attention to intercropping and multiple cropping of which some examples are found in the manure legislation and CAP-greening measures (grass and legumes under main crop).
- A high number of practices in the category **organic matter/nutrient management** were both listed in policy documents and by stakeholders.
- Regarding **tillage and traffic**, forms of non-inversion tillage were mentioned in both analyses, but stakeholders also referred to practices not in policy such as controlled traffic farming.
- Precision agriculture, agroforestry and organic farming were mentioned as promising **farming systems** both by policy and by stakeholders, but stakeholders also put more emphasis on agro-ecological farming and conservation farming.
- Regarding **water management**, policy documents put a focus on small scale water infrastructures such as ponds and dams and wetlands, while stakeholders mentioned other practices such as increasing water tables, irrigation and flooding.

4.3 Recommended instruments to achieve the aspirational goals

In addition to management practices, stakeholders were asked to suggest other 'instruments' to achieve aspirational goals (Table 7). These, together with some instruments and recommendations mentioned in Box 1, could be summarised as follows:

- A **systems thinking** in function of soil quality and the long term impact on the environment is essential;
- In general, **payments for ecosystem services** were mentioned and more in particular payments **for storing carbon** through a carbon market. It was stressed that a certification/accounting method is needed that is cost-effective yet accurate. A green deal for agroforestry and facilitating the supply and valorisation of organic residue streams (e.g. wood chips, compost) was suggested. To protect peat, carbon hotspots should be mapped and business models should be developed for these sites.
- The supply and use of **organic matter** could be facilitated.
- Stakeholders pointed out that **seasonal rent** can be detrimental for soil quality, perhaps more than soil management practices. The stakeholders think that a **soil passport** could be helpful to track soil quality on these field parcels.

- Some stakeholders also point out that we should **combine multiple data sources** to better detect problems with soil quality and to provide targeted solutions.
- Different soil challenges could be tackled by **stimulating chains for soil beneficial crops.** For soil carbon increase think for instance of deep rooting crops, crops with large root systems and with a large amount of stable C residues, main crops that are harvested early to obtain a well-developed cover crop afterwards and multiple cropping. N_20 emissions could be avoided by stimulating crops which require low nutrient input and to reduce erosion risks less erosion sensitive crops could be grown.
- Integration with **spatial planning** policies and property rights is important to prevent soil sealing.
- **Nature based solutions for soil contamination** and investment support for mechanical weeding should help to remediate and prevent soil pollution.
- **Education and farm-specific advice** are mentioned to tackle soil erosion and to improve soil structure.

Table 7 *Other instruments to achieve aspirational goals as suggested by stakeholders(apart from soil management practices listed in Table 6)*

	Possible instruments to achieve aspirational goal
Maintain/increase SOC	Several stakeholders mention a **carbon market** for rewarding farmers who sequester carbon. • Several stakeholders such as banks, landlords, local governments, water companies, suppliers, processing industries, retail, consumers and players outside the agrifood chain can play a role. • Market Based Domestic Carbon offsetting programmes need to be transparent in accounting carbon (no double accounting), a certification method and organisation is needed. • In order to establish a carbon market a cost-effective yet accurate SOC monitoring system at the field/farm level is needed. • An European carbon market would be beneficial because this would guarantee the level playing field in Europe. **Green deal agroforestry** – voluntary engagement from different stakeholders in the production -to-consumer chain to increase the agroforestry surface in Flanders with all the ecosystem services related. The **supply of organic matter** could be facilitated. Financial tools could ensure that it is economically more profitable to sequester carbon than to remove e.g. crop residues for biobased fuels and the bioeconomy. Facilitate the use of compost, organic fertilisers and bokashi. Increase the use of **valorisation of waste streams** such as wood chips to increase SOC. Reduce **tillage** depth and overall reduce the amount of tillage operations.
Avoiding N_2O, CH_4 emissions	Regulatory instruments in the framework of the manure legislation (Nitrates Directive) Manure treatment. Adjusting feed ration.

	Possible instruments to achieve aspirational goal
Avoid peat degradation	There should be **no arable land on peat soils** Action plan to protect **carbon hotspots** such as peat areas and wet grasslands based on accurate mapping of these hotspots and appropriate business models for farmers on these sites
Avoid soil erosion	Contour farming, contour agroforestry, or planting hedgerows or food/crop trees on contour/keyline. **Landscape approach** to reduce run-off with landscape elements where water can infiltrate so that downstream erosion is reduced. Rotations with **less erosion sensitive crops** in between crops that are more erosion sensitive. **Paying** farmers for maintaining soil carbon or increasing **SOC** is also beneficial for avoiding soil erosion. **Continuous efforts to improve techniques** that combat soil erosion on-site in co-creation with farmers. These continuous efforts are needed to keep the attention of farmers towards the problem. It would also be better if they could get access to **farm-specific advice**. This needs advisors that are specialized in the matter.
Avoid soil sealing	This is/needs to be embedded in spatial policies: e.g., decrease % of sealed surface or minimum % of non-sealed surface during infrastructure works. There are many different tactics from the field of planning law and property rights that could be beneficial for the prevention of soil sealing.
Avoid salinisation	/
Avoid acidification	/
Avoid contamination	For all soils, including agricultural soils: Reduce/manage the already present soil contamination (including in groundwater, sediment, …) by soil management based on **nature based solutions** (if applicable and available), e.g. bioremediation, fytoremediation, mycoremediation, … Some of these of solutions are still in development phase. To avoid further spreading of contaminated soils, information on soil quality (including contamination) should be readily available to all users of land. **Monitoring** data are needed to complete databases. We foresee in the future more emphasis on **management of contaminated sites**, i.e. prevention of further spreading and exposure, rather than excavation, using the soil certificate as instrument to achieve this. **Quality** of brought in soil (contamination, stone content) for relief changes should be ensured. The investment support for **mechanical weeding machinery** should also be available for older farmers (the current financial compensation is only available for young farmers at the moment).

	Possible instruments to achieve aspirational goal
Optimal soil structure	Deep tillage To **limit the weight of machinery** because agricultural machines get larger and larger and heavier and heavier. This is beyond the carrying capacity of soils. To adjust the conditions in **contracts** for supplying the agricultural products so that trafficking under unfavorable soil moisture conditions can be avoided. More attention in **education** of farmers, advisors and other yard visitors.
Enhance soil biodiversity	Stimulating programme for owners of private gardens aiming for behavioural change. This is important because private gardens are 9-10% of the area in Flanders. This links with SOC, avoiding soil sealing, contamination and water storage capacity. Financial **remuneration for increasing SOC** (see above). To oblige **cover crops** when not obliged yet by the manure decree.
Enhance soil nutrient retention/use efficiency	/
Enhance water storage capacity	Proper bank management, more pastures that can be flooded, contour farming pools, to financially **renumarate farmers that increase SOC** (see above).
General	**Soil passport** (currently being developed by the policy department of agriculture and ILVO) and BodemIdee developed by Interreg Leven(de) bodem. One stakeholders says to miss the link between the soil, the soil type, the landscape (the natural system including water) and the soil management solutions. If you consider the **whole system** you can work on an integrated management (crop choice, fertilization methods, choice of machinery). There should be more attention to agricultural soils in spatial planning. The most suitable soils should get the most suitable land use and management (cfr permaculture principles) Binding thresholds in e.g. CAP To compensate farmers for **ecosystem services** (so not only for carbon).

4.4 Prioritization of soil challenges

The stakeholders had to prioritize the key soil challenges in Flanders for the upcoming decades. This prioritization exercise was not only done by the stakeholders who completed this questionnaire but also two other questionnaires that were launched at the same time. A total of 19 organisations have done the scoring (see ILVO mededeling 272) and the combined results are shown in Figure 5.

Maintaining/increasing soil organic carbon (SOC) was by far the most important soil challenge for the upcoming decades according to the stakeholders. This was followed by enhancing water storage capacity, enhancing soil biodiversity and enhancing soil nutrient retention/use efficiency. Avoiding soil erosion and ensuring an optimal soil structure were priorities five and six.

Unlike for SOC, soil erosion and soil nutrients, there are no clear policies nor targets for enhancing water storage capacity, enhancing soil biodiversity and ensuring optimal soil structure yet. Water storage is an emerging topic the past years due to longer drought spells that were experienced and the expectations that drought problems might even increase in the future due to climate change. No clear differences between stakeholder groups were detected.

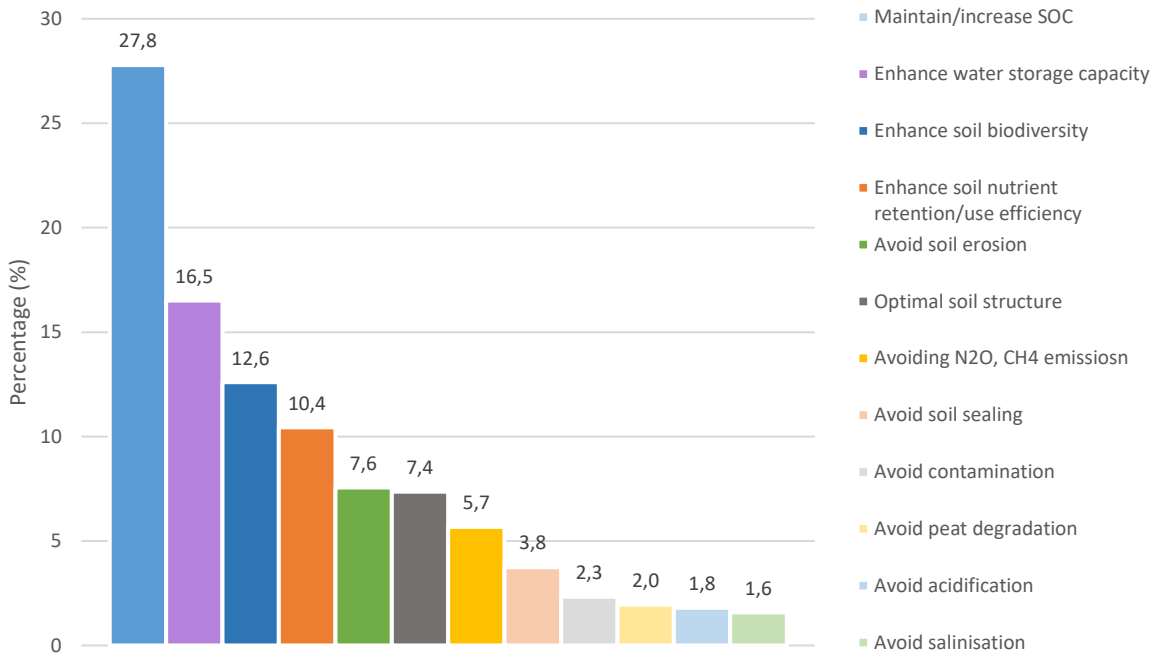


Figure 5: *Prioritization of soil challenges by stakeholders for Flanders, who answered the question 'What do you expect that will be the main soil challenges that are most relevant for Flanders in the upcoming decades' (scored by 19 organisations)*

5. Knowledge needs

From the policy analysis and stakeholder input some knowledge needs could be extracted.

Agricultural soils in general

- Monitoring of soil quality is needed and we should get a better insight in the evolution of soil challenges.
- Data driven soil management and the use of decision support tools should be enhanced, as well as transparency and use of big data. How can multiple data sources such as soil scans, tractor, UAV and satellite remote sensing data and weather data be combined to better detect problems with soil quality so that targeted solutions could be implemented to improve soils and crop yield potential.
- The provision of soil ecosystem services should be compensated and business models developed
- How to integrate soil use/management with spatial planning and to create a holistic vision?
- What is the impact of seasonal rent on soil quality?

Research needs per soil challenge are listed below, with soil challenges in decreasing order of importance (see prioritistation 4.4)

Maintaining/increase soil carbon (27.8%)

- Policy or market based payments for soil carbon sequestration: well established certification/accounting methods that are accurate yet cost-effective should be established;
- Mapping of carbon hotspots.

Enhancing soil water storage capacity (16.5%)

- What is the link with other soil challenges?
- How to increase water holding capacity and make soils more drought resistant;
- What are strategies for water retention in farmland. How can we minimize moisture loss and learn from arid countries?
- How to formulate targets and monitor?

Soil biodiversity (12.6%)

- We still know very little on soil biodiversity (status, evolution, role) and how to enhance it to a desired level. These insights are needed to develop proper legislation and targets;
- What are good policy instruments to enhance soil biodiversity. There a no good policy instruments at the moment to enhance biodiversity;
- Should we strive to enhance soil biodiversity in general or should we stimulate specific functional groups.

Soil erosion (7.6%)

- What should be targets for soil erosion to reach land degradation neutrality?
- What is the impact and prevention of wind erosion?
- How to improve farming practices to reduce soil erosion, including contour farming and contour agroforestry/hedges?

Soil structure (7.4%)

- How to monitor soil structure and formulate good policy targets? A policy is important in the light of upcoming climate change.

N_2O emissions (5.7%)

- More accurate and evidence based methods for N_2O emissions inventory are needed;
- What is the impact of new crops such as legumes, legume cover crops and natural fibres on N_2O emissions?

Soil contamination (2.3%)

- What is the extent of diffuse contamination?
- How to apply nature based solutions to remediate soil contamination?

Soil salinization (1.6%)

- Not much known in Flanders yet (prevelance, how to prevent), but salinization can become an issue in the future, and thus requires further research.

6. Conclusions

In Flanders, most policies that affect agricultural soils and soil management are regional matter and many are derived from EU policies. Specific for Flanders is the Decree on soil remediation and soil protection (BD) that focuses on soil contamination and soil erosion (SD-E). Besides, the importance of soils is also highlighted in longer term strategies, the spatial policy plan, policy notes and action plans. Despite the fact that soils are mentioned and targeted in many policies, an overarching soil policy framework is missing in Flanders.

The largest focus in **current policy** is on soil organic carbon, soil erosion, soil contamination, and nutrient retention/use efficiency. SOC and nutrient retention/use efficiency are also in the top four of **soil challenge priorities** for the upcoming decades, but the stakeholders also prioritized water storage capacity and enhancing soil biodiversity, for which policy and targets are largely missing at the moment.

There are few quantified **targets** that explicitly address agricultural soil challenges in Flanders, i.e. on N_2O emissions, soil residual nitrogen in autumn and soil sealing in agricultural area. There is a clear target for carbon in the entire LULUCF sector (no-debit in the 2021-2030 period), which includes agricultural soils, but for agricultural soils in particular targets remain vague, i.e. more carbon storage by 2030 or carbon content of agricultural soils in optimal zone by 2050. It is unclear how much more carbon should be stored and what the optimal zone is that should be reached. Several policies aim at less erosion and although an indicator has recently been launched, the specific target remains unquantified. Erosion is also an indicator for the land degradation neutrality target but also for this target the minimum soil erosion that could be tolerated is not defined yet. Policy documents mention the need to increase water holding capacity of soils but there are no quantified targets nor indicators yet.

In Flanders, farmers need to take frequent soil samples for various policies (e.g., ND, A-CC) but there is **little soil monitoring at the regional level**, so little is known on the evolution of the soil challenges. Currently, there is no systematic statistically-sound soil monitoring, although policy documents mention the ambition to establish a soil carbon monitoring network and a monitoring network is designed[8]. In September 2020, a new soil erosion indicator was launched to monitor the evolution in

[8] Sleutel S., D'Hose T., Lettens S., Ruysschaert G., De Vos B. 2021. ACTUALISATIE EN VERFIJNING VAN DE ONDERBOUWING VAN EEN METHODIEK VOOR DE SYSTEMATISCHE MONITORING VAN KOOLSTOFVOORRADEN IN DE BODEM (opdracht OMG/VPO/BODEM/TWOL/2017/1) – Eindrapport. Vlaams Planbureau voor Omgeving, Brussel.

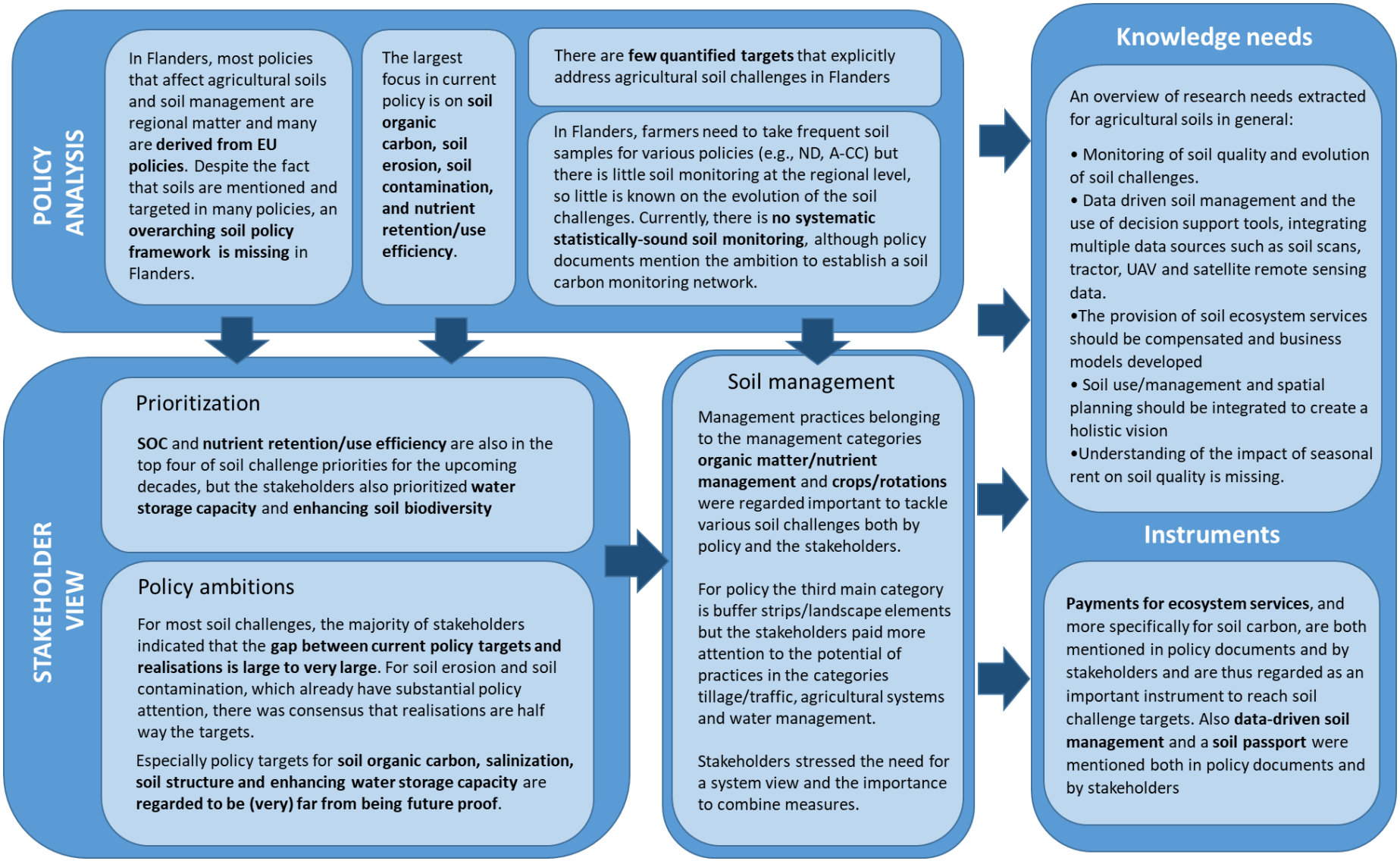
soil erosion risk[9]. The weighted average soil residual nitrate in autumn and the percentage of field parcels with an available P content above the target is monitored to track the progress of the manure action plan.

For most soil challenges, the stakeholders indicated that the **gap between current policy targets and realisations** is large to very large. For soil erosion and soil contamination, which already have substantial policy attention, there was consensus that realisations are half way the targets. For soil salinization there was no gap because there are no policy targets yet. Votes for soil biodiversity were divided. Especially policy targets for soil organic carbon, salinization, soil structure and enhancing water storage capacity are regarded to be **(very) far from being future proof.**

Payments for ecosystem services, and more specifically for soil carbon, are both mentioned in policy documents and by stakeholders and are thus regarded as an important **instrument to reach soil challenge targets**. Also data-driven soil management and a soil passport were mentioned both in policy documents and by stakeholders and some stakeholders hope a soil passport could help to improve soil quality on field parcels with seasonal rent. Other instruments suggested by stakeholders include the stimulation of chains for soil beneficial crops, the integration of soil policies with spatial planning, facilitating the valorization of organic residue streams, a green deal for agroforestry, investing in farm-specific advice and using a landscape approach.

Regarding **soil management practices** to reach soil challenge targets, management practices belonging to the management categories organic matter/nutrient management and crops/rotations were regarded important to tackle various soil challenges both by policy and the stakeholders. For policy the third main category is buffer strips/landscape elements but the stakeholders paid more attention to the potential of practices in the categories tillage/traffic, agricultural systems and water management. Stakeholders stressed the need for a system view and the importance to combine measures.

[9] Swerts, M., Deproost, P., Renders, D., Oorts, K., 2020. Bodemerosierisico-indicator Vlaanderen (2008-2019). Departement Omgeving, Brussel.


POLICY ANALYSIS
In Flanders, most policies that affect agricultural soils and soil management are regional matter and many are derived from EU policies. Despite the fact that soils are mentioned and targeted in many policies, an overarching soil policy framework is missing in Flanders.
The largest focus in current policy is on soil organic carbon, soil erosion, soil contamination, and nutrient retention/use efficiency.
There are few quantified targets that explicitly address agricultural soil challenges in Flanders
In Flanders, farmers need to take frequent soil samples for various policies (e.g., ND, A-CC) but there is little soil monitoring at the regional level, so little is known on the evolution of the soil challenges. Currently, there is no systematic statistically-sound soil monitoring, although policy documents mention the ambition to establish a soil carbon monitoring network.
STAKEHOLDER VIEW
Prioritization
SOC and nutrient retention/use efficiency are also in the top four of soil challenge priorities for the upcoming decades, but the stakeholders also prioritized water storage capacity and enhancing soil biodiversity
Policy ambitions
For most soil challenges, the majority of stakeholders indicated that the gap between current policy targets and realisations is large to very large. For soil erosion and soil contamination, which already have substantial policy attention, there was consensus that realisations are half way the targets.
Especially policy targets for soil organic carbon, salinization, soil structure and enhancing water storage capacity are regarded to be (very) far from being future proof.
Soil management
Management practices belonging to the management categories organic matter/nutrient management and crops/rotations were regarded important to tackle various soil challenges both by policy and the stakeholders.
For policy the third main category is buffer strips/landscape elements but the stakeholders paid more attention to the potential of practices in the categories tillage/traffic, agricultural systems and water management.
Stakeholders stressed the need for a system view and the importance to combine measures.
Knowledge needs
An overview of research needs extracted for agricultural soils in general:
• Monitoring of soil quality and evolution of soil challenges.
• Data driven soil management and the use of decision support tools, integrating multiple data sources such as soil scans, tractor, UAV and satellite remote sensing data.
•The provision of soil ecosystem services should be compensated and business models developed
• Soil use/management and spatial planning should be integrated to create a holistic vision
•Understanding of the impact of seasonal rent on soil quality is missing.
Instruments
Payments for ecosystem services, and more specifically for soil carbon, are both mentioned in policy documents and by stakeholders and are thus regarded as an important instrument to reach soil challenge targets. Also data-driven soil management and a soil passport were mentioned both in policy documents and by stakeholders

Annex I: EJP SOIL glossary

Safeguarding a shared EJP SOIL language is important to ensure comparability between all stakeholders and regions. To enable this, a glossary and a soil concept framework was developed, linking management practices, soil challenges, soil functions and overarching EJP SOIL goals.

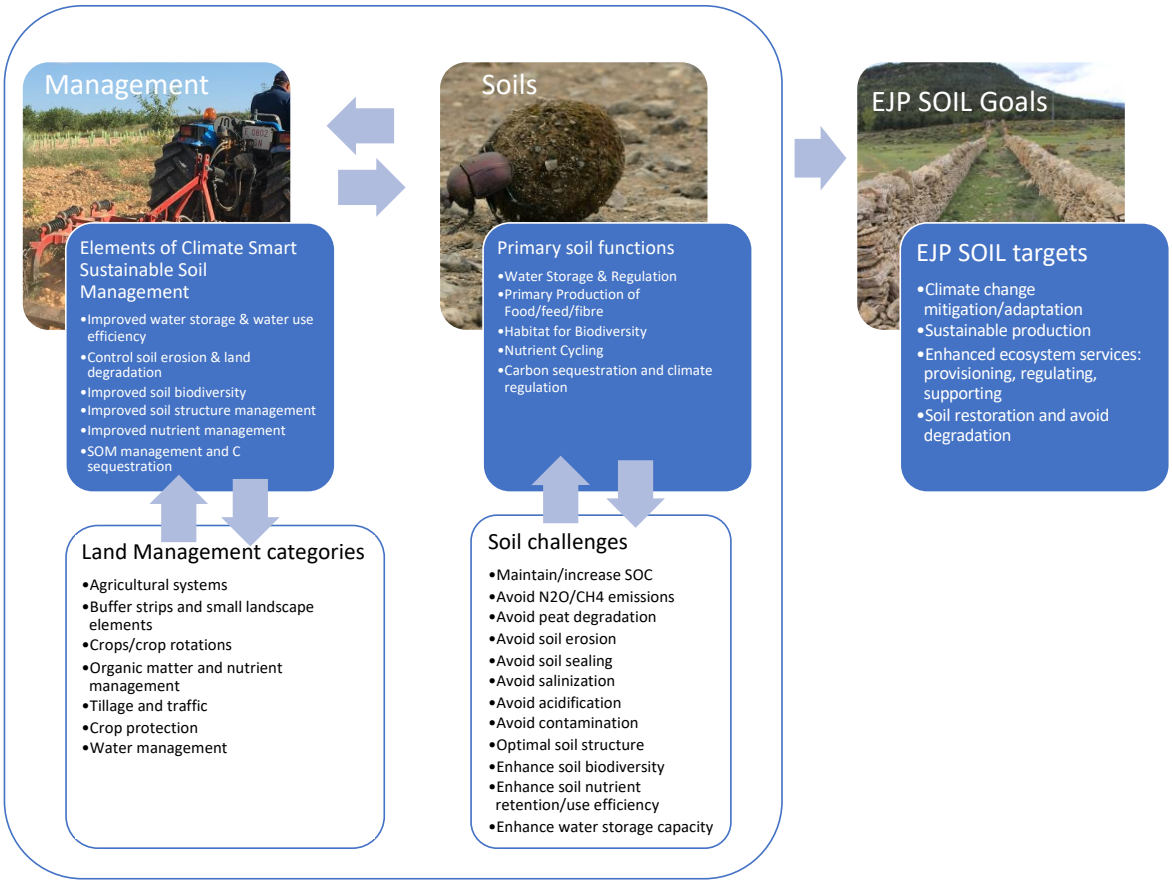


Figure : *Soil Concept Framework: This linkages diagram illustrates how local land management choices can influence the elements defining climate smart sustainable soil management. Secondly, the diagram shows the interlinkage between the primary soil functions and soil challenges; and that the local soil conditions together impact and are impacted by the management choices made on a specific location. The knowledge on the interaction on climate smart sustainable soil management and the soil challenges/functions will enable to reach the EJP SOIL goals.*

Aspirational goal: A hope or ambition of achieving something. In this document, aspirational goals are the long-term goals (2050) to work towards, expressed by national and EU stakeholders.

Climate Smart and Sustainable Agriculture (CSSA): an approach, developed by the FAO, that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate (FAO, 2020).

Climate Smart Sustainable Soil Management – soil management for CCSA. The elements Climate smart sustainable soil management are improve water storage & water use efficiency, control soil erosion & land degradation, improved soil biodiversity, improved soil structure management,

improved nutrient management and soil organic matter (SOM) management for C-sequestration (Paustian et al., 2016[10]).

Land management categories:

a) **Crops and crop rotations**
Choices that farmers make regarding the crop types and rotations; e.g. cover crops, shift towards more protein crops, grasslands;

b) **Organic matter and nutrient management**
Choices that farmers make regarding, e.g., fertilization types and doses, precision fertilization techniques, crop residue management, on-farm composting, manure treatment, crop residue management and manure treatments;

c) **Tillage and traffic**
Choices that farmers make regarding types, depth and intensity of tillage practices such as ploughing vs. non-inversion tillage, contour ploughing, intensity of seedbed preparation Traffic choices include size and weight of field machinery, tires and inflation pressure regulation, field traffic intensity.

d) **Crop protection**
Choices that farmers make regarding pest, disease and weed control, e.g. mechanical weeding vs. chemical weed control.

e) **Water management**
Choices that farmers make regarding for example irrigation, regulating ground water levels for rewetting or drainage

f) **Agricultural systems**
Sometimes farmers make clear choices towards a certain farming system, such as agro-ecological production methods, agroforestry, conservation agriculture or organic agriculture. These systems have a holistic approach and integrate choices regarding crops/rotations, organic matter and nutrient management, tillage and traffic, and crop protection. The reason why agricultural systems are a separate category here, is that they are often mentioned in policy documents and are understandable by multiple stakeholders.

g) **Buffer strips and small landscape elements** (eg grass buffer strips, hedges).
Buffer strips and small landscape elements do not only have a local impact, but they affect also soil functions and processes and ecosystem services in the wider area. Small landscape elements might be a source of organic residues that can be used to improve soils in the area.

Goal: something important that policy intends to achieve in the future, even though it may take a long time. The **overarching EJP goals** are: 'good agricultural soil management for: climate change mitigation and adaptation, sustainable production, ecosystem services and less soil degradation.'

Indicator: Parameter used to quantify and valuate impacts of agricultural soil practices on soil quality and the environment to draw conclusions for the farming practice or agricultural policy (modified after Piorr, 2003)[11].

[10] Paustian, K., Lehmann, J., Ogle, S., Reay, D., Robertson, G. P., & Smith, P. (2016). Climate-smart soils. *Nature*, *532*(7597), 49-57.

[11] Piorr, H. P. (2003). Environmental policy, agri-environmental indicators and landscape indicators. *Agriculture, Ecosystems & Environment*, *98*(1-3), 17-33.

Policy ambition: In this document, the term policy ambition refers to the broader description of what a policy package (at the EU, national or regional level) wants to achieve and how. It assembles some (quantified) targets, policy monitoring tools, management practices encouraged by policy and other policy instruments.

Policy instruments the instruments/tools that are used to reach policy targets. Four categories of instruments are typically identified: mandatory regulation, economic instruments, voluntary approaches and educational/informational instruments (Cocklin et al., 2007[12], McNeill et al., 2018[13]). This includes financing mechanisms such as carbon markets and management practices that will be encouraged.

Policy monitoring tools: the tools that are used or need to be developed to monitor policy targets.

Soil threats and soil challenges: soil threats can be defined as processes or agents that could deteriorate (some of) the functions of soils and the services that soils provide. For the European soils major soil threats are: soil erosion by water and wind, decline in soil organic matter in peat and mineral soils, soil compaction, sealing, contamination, salinization, desertification, decline in soil biodiversity (EU, 2006[14]). Each soil threat represents also a challenge to be overcome for preserving soil from degradation. In this document we will refer to these matters as soil challenges. By converting the negative into the positive, farmers can optimise primary soil functions and related ecosystem services (see glossary for an overview of the **agricultural soil ecosystem services (ASES**)).

Soil challenges: different soil processes that need to be prevented or reinforced to prevent soil degradation and to maximize soil functions and ecosystem services and to reach policy ambitions, aspirational goals and EJPSoil goals:

- Maintain/increase SOC
- Avoiding N2O, CH4 emissions from soils
- Avoid peat degradation
- Avoid soil erosion
- Avoid soil sealing
- Avoid salinisation
- Avoid acidification
- Avoid contamination
- Optimal soil structure
- Enhance soil biodiversity
- Enhance soil nutrient retention/use efficiency
- Enhance water storage capacity

Target: Specific goals that have to be reached within a given time frame. Usually, targets are quantified and to be reached within a given time frame e.g., to decrease greenhouse gas emissions by 35% by 2030 compared to 2005.

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[12] Cocklin, C., Mautner, N., & Dibden, J. 2007. Public policy, private landholders: Perspectives on policy mechanisms for sustainable land management, Journal of Environmental Management 85(4): 986-998.

[13] McNeill, A., Bradley, H., Muro, M., Merriman, N., Pederson, R., Tugran, T., Lukacova, Z., (2018), Inventory of opportunities and bottlenecks in policy to facilitate the adoption of soil-improving techniques. Scientific Report No. 9, http://www.soilcare-project.eu

[14] European Commission (EC): Communication from the Commis- sion to the Council, the European Parliament, the European Eco- nomic and Social Committee and the Committee of the Regions, Thematic Strategy for Soil Protection, COM 231 Final, Brussels, 2006.

Annex II: Questionnaire sent to the stakeholders

Stakeholder questionnaire Flanders
EJP Soil Task 2.1

Validating current policy ambitions and defining aspirational goals on agricultural soils

Questionnaire 1: "Toekomstvisie"

EJP SOIL

*This questionnaire is part of the European Joint Programme Soil (**EJP SOIL)**. The overall objective of EJP SOIL is to provide solutions for sustainable soil management that contribute to addressing key societal challenges including climate change and future food supply. Please see (www.ejpssoil.org) for further information.*

*EJP SOIL invites you to participate as a valuable **stakeholder** and to engage in the programme to represent the breadth of agricultural systems and soil management practices in your country.*

*The information you provide will feed into an **EU roadmap** that will reflect the knowledge needs in each region in Europe and that will outline the key research and capacity building priorities, supporting soil data harmonisation, policy-making and knowledge implementation.*

Background information questionnaire

The specific aim of this questionnaire is (i) to **validate** the policy analysis of current policy ambitions and realisations on agricultural soils and soil management in your country (here: Flanders), (ii) to evaluate the **realisations** of the current agricultural soil policy and (iii) to set the **aspirational** future goals.

Step-by-step

The questionnaire template comprises **5 steps**: (0) Background information, (1) Policy framework validation, (2) policy realisation and defining aspirational goals, (3) how to achieve policy aspirational goals and (4) policy prioritization.

IMPORTANT:

The answers you provide should be your own opinion based on your knowledge and expertise and do not have to be official statements of your organisation (if applicable). In the final report, results will be clustered by stakeholder group only, so it will not be possible to trace the answers back to your name, institute or organisation.

☐ I confirm that I have read and understood the objective of the questionnaire part of the EJP SOIL program, and agree that my answers will be processed anonymously.

Questions?

Should anything be unclear, please contact the national coordinator for this task, being Greet Ruysschaert.

Thank you for your valuable inputs!

Step 0: Background information

In this introductory step we ask you to provide some basic background information by answering the questions in the table below. Names are for the track record of the national coordinator of this task only, because there might be an interview afterwards for clarifications. In the final and public report, results will be clustered by stakeholder group only, so it will not be possible to trace the answers back to your name, institute or organisation.

Remark: This table is identical for all parallel questionnaires of the EJP Soil program. If you are participating in the different questionnaires the table should only be filled once, **except for your name and institute/organisation**.

Background information table

Background information	
Can you provide your full name and job title?	*Name, Job title*
What stakeholder group do you identify yourself with most?	☐ *National European soil partnership representatives* ☐ *National policy stakeholders (local governance and policy implementing representatives)* ☐ *Research communities* ☐ *Research funders* ☐ *Middle & Higher educational institutions* ☐ *Farmer Schools* ☐ *Farmers and demonstration farms* ☐ *Advisors* ☐ *Farmers' organisations* ☐ *Agro-industry* ☐ *Laboratories, National science testing, Verification centres etc.* ☐ *Industry, Supply & Retail* ☐ *NGOs and community-based organizations*
If applicable, what institute or organisation do you work for?	*Institute/organisation*
What is the relevance of agricultural soils and soil management within your job?	*Relevance agricultural soils and soil management*

Have you completed the questionnaire on your own or have you consulted any colleagues? How many persons did you consult? And who are these persons? (*To be clear: it is not mandatory for this questionnaire that you have consulted your colleagues. This should not be an official answer of your organisation, rather your opinion based on your expertise*)	*[to be filled after finishing the questionnaire]*
Other (general remarks)	*[open question]*

Step 1: Validation of the policy analysis report.

Important note: In this step we ask an objective assessment of the policy analysis conducted by the project partners. The analysis reflects what is written in official policy documents. **We do NOT ask for your opinion**. Your opinion will be asked for in the steps 2, 3 and 4.

Even if you are not familiar with policy documents and are not able to validate this analysis, we would like to ask you to read through this step, so that each stakeholder can start with the same understanding at the next steps.

What: Validation of the policy analysis drafted by the national project partners attached in **Annex I**. This includes, where necessary, complementing the draft with your expert knowledge. *(Note this Annex is not attached here, see section 3 of the report).*

How: Key validation questions that should be addressed are:

- Are all policies targeting agricultural soils and soil management included – indirect and direct policies? And if available, are the targets, currently used indicators and current status of the indicators complete? Are all policy monitoring tools and policy instruments that are mentioned in the policy documents listed (table 2)?

- Are the policy packages and targets correctly positioned in the soil challenges – Climate smart sustainable soil management cross table (table 3)?

- If specified, are the soil management practices mentioned in the policy documents correctly indicated (table 4)?

- No market-based initiatives were identified in the analysis of Flanders. Is there any market-based initiative that is clearly linked with soil, fertiliser or manure management that should be included in your opinion?

For the validation of the draft policy analysis, a review table is provided. This table allows to structurally answer the key questions listed above. **The question is answered by indicating "YES" or "NO" in the appropriate cell.** In case the answer is "NO" provide suggestions and feedback in this table to complete or correct the draft. Additionally, general remarks can be provided in the last column.

STEP 1 *- Validation table*

		Complete	***Correct***	***General remarks***
Table 2 Are all policies targeting agricultural soils and soil management included – indirect and direct policies? And if available, are the targets, currently used indicators and current status of the indicators complete? Are all policy monitoring tools and policy instruments that are mentioned in the policy documents listed?	*All policies included*			
	Policy targets listed			
	Policy indicators listed			
	Current status of indicators listed			
	Policy monitoring tools listed			
	Policy instruments listed			
Table 3 Are the policy packages and targets correctly positioned in the soil challenges – Climate smart sustainable soil management cross table (table 3)?		*Not applicable*		
Table 4 If specified, are the soil management practices mentioned in the policy documents correctly indicated (table 4)?		*Not applicable*	*Not applicable*	
Overall: is there any main **market-based initiative** with a clear link to soil, fertiliser or manure management that is missing from the policy analysis?			*Not applicable*	

Step 2: Policy realisation and defining aspirational goals

Important note: *in contrast with the first step of the questionnaire, we do ask for* ***your stakeholder opinion*** *in the following steps.*

What: The soil policy assessment, validated in step 1, provides an overview of the current policy ambitions. For some policy targets, indicator values are available that track the current status of policy targets, but that is not the case for all policy targets. In this step we try to identify **the potential gap between the current realisation of the policy ambitions and the targets that are set**. In case there is no indicator value, we ask to evaluate the policy based on your expert knowledge.

At the same time, one could also question **whether the current policy ambition is sufficient in light of the societal challenges** (climate change, land and soil degradation, loss of ecosystem services) that we face towards 2050 and if not, where new policy targets are required? This is addressed in question 2, referred to as 'futureproof'.

The aim of this step is to identify the current realisations and aspirational targets for the soil challenges, by addressing these two central questions:

(Q1) How wide is the gap between the current policy target and realisation?

(Q2) Are the current policy targets futureproof with a horizon to 2050?

How*:* We prepared a policy evaluation exercise for the different soil challenges (Table 5).

Question 1

The first 2 columns of Table 5 (grey), are completed by the national project partners from the analysis of policy documents (validated in step 1) to show the current targets and status. In the third column a Likert scale is presented for evaluating the realisation of the current policy in sight of the current policy ambition for the different soil challenges. The advantage of this Likert scale is that it allows the evaluation of policy realisations, even for policies without clearly defined indicators, but the Likert scale should also be used when indicators are available.

The gap between the policy target and realisation is **very large**	The gap between the policy target and realisation is **large**	The realisation is **halfway** the policy target	The gap between the policy target and realisation is **small**	The policy target is already **achieved**
1	2	3	4	5

Question 2

After evaluating the current policy realisations, the aim is to think 'out-of-the-box', independent of the current policy limits, and to set the **aspirational goals by 2050.**

To answer the question, whether the current policy targets are futureproof with a horizon to 2050, another Likert scale is presented:

The policy ambition is **already** futureproof	The policy ambition is **almost** futureproof	The policy ambition is **far** from being futureproof	The policy ambition is **very far** from being futureproof
1	2	3	4

For every vote in table 5 it is important that you also **provide a short argumentation** for your vote. The argumentation can define whether the vote was scientifically supported or rather an intuitive choice based on your expert knowledge.

In case you have no insight on the soil challenge at all, you can leave the specific soil challenge blank and explain this in the argumentation, but we do encourage you to complete as much as possible.

Table 5 is provided on the next page.

***STEP 2 - Table 5**: Current policy realisations and aspirational goals per soil challenge (for abbreviation of policy packages, see Annex I – table 1). **SS**: soil specific; **SAS**: specific for agricultural soils only; **NS**: non-soil specific, the target includes soils but is broader than agricultural soils only*

Soil challenge	Current policy target	Current status of policy targets (when Indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Argumentation	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Argumentation
			1	2	3	4	5		1	2	3	4	
			Very large	*Large*	*Halfway*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
Maintain/increase SOC	**A-CC**: soil carbon content (% C) of field parcels above minimum threshold, pH in optimal zone (**SAS**) **A-CC**: When %C>1.7% +pH is optimal, erosion sensitivity class of the field parcel is lowered (**SAS**) **A-GM**: Reference ratio of area permanent grassland (5 years or older) / total area of CAP farmers (excl. organic farmers) in 2015 (based on area data of 2012) should not decrease with more than 5% at the regional level (Flanders) (**SAS**) **A-RD**: Focus area 5E: 370 ha of agricultural and forestry land under management contracts to conserve and sequester carbon (2014-2023 period) (**SAS**); i.e. agroforestry (150 ha by 2020) and afforestation of agricultural land (only those partly paid by PDPO means) **FECP**: LULUCF: no debit in 2021-2030 period (**NS**); more carbon storage in agricultural soils (**SAS**) **FLS**: C-content of agricultural soils is in optimal zone by 2050 and C-content further increases or remains at high level (**SAS**); Carbon hotspots (peat areas and alluvial forest) are protected by 2050 and disturbed systems are being recovered(**SS**) **ND:** to increase soil quality by stimulating measures that increase soil organic matter content (**SAS**), e.g. cover crops, farmyard manure, (farm) compost **BM25:** Maintaining and increasing soil organic carbon content of the soil by 2025 (**SS**) **PN-A/PN-E**: Soils in Flanders may not loose carbon in the upcoming 10 years (2020-2030) (**SS**). Therefore, carbon loss from agricultural soils is strongly reduced (**SAS**).	reference ratio = 27.99%; 27.36% in 2019 Agroforestry 67 ha subsidised in the 2014-2018 period Afforestation: 46 ha subsidized in the 2014-2018 period											

Soil challenge	Current policy target	Current status of policy targets (when Indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Argumentation	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Argumentation
			1	2	3	4	5		1	2	3	4	
			Very large	*Large*	*Halfway*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
Avoiding N_2O, CH_4 emissions from soils	**A-RD**: Focus area 5D: 1.7% (increased to 2.88% in 2019) of agricultural land under management contracts to reduce greenhouse gas emissions and/or NH_3 (maximum to be reached in 2014-2023 period) (**SAS**), e.g. crops that need less fertilization such as flax and hemp, legume crops **FECP**: Agricultural sector: soil emissions (N_2O) should decrease with 0.27 Mton CO_2eq = 19% by 2030 compared to 2005 (**SAS**) **FLS**: Agricultural sector: -40% non-energetic greenhouse gas emissions (GHG) by 2050 compared to 2005 (**NS**) (indicative but non-binding target)	Max. % of agricultural land under contract for focus area 5D: 1.73% in the 2014-2018 period N_2O-emissions kton CO_2eq: -4.8% in 2017 vs 2005 +3.2% non-energetic GHG expressed in CO_2 eq. in 2018 compared to 2005											
Avoid peat degradation	**FLS:** Carbon hotspots (peat areas and alluvial forest) are protected by 2050 and disturbed systems are being recovered(**SS**) **BM25**: Protecting global peatlands by stimulating renewable substrates for consumers and horticulture (**SS**)												
Avoid soil erosion	**A-CC**: Less erosion by water with focus on on-site erosion control (**SAS**) **A-RD**: Focus area 4C 1.36% of agricultural land under management contracts to improve soil management and/or prevent soil erosion (maximum to be reached in 2014-2023 period), e.g. grass strips, strategic grasslands, dams, organic farming (**SAS**) **SDE-E**: to lower off-site erosion damage (**SAS**) **SDG30**: Land degradation neutrality by 2030 in Flanders (net no extra degraded land) with soil erosion as indicator (**SAS**)	Max. % of agricultural land under contract for focus area 4C: 0.98% in the 2014-2018 period											
Avoid soil sealing	**SDG30**: Land degradation neutrality by 2030 in Flanders (net no extra degraded land) – with soil sealing as one of 3 indicators (**SS**) **BRV**: % sealed surface -20% by 2050 compared to 2015 in land use categories agriculture, nature and Forest (**SS**)	Soil sealing (area artificial soil covering/total area): 16% in 2016 (**SS**)											
Avoid salinisation													

Soil challenge	Current policy target	Current status of policy targets (when Indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Argumentation	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Argumentation
			1	2	3	4	5		1	2	3	4	
			Very large	*Large*	*Halfway*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
Avoid acidification	**A-CC**: soil carbon content (% C) of field parcels above minimum threshold, pH in optimal zone (**SAS**) **A-CC**: When %C>1.7% +pH is optimal, erosion sensitivity class of the field parcel is lowered (**SAS**)												
Avoid contamination	**SDG30**: Land degradation neutrality by 2030 in Flanders (net no extra degraded land) with soil contamination as indicator (**SS**) **SUP**: Regulating the sustainable use of pesticides, implicitly aiming to reduce the impact on soil, soil contamination and water (**SS**); To ensure that type (licensed), amount and concentrations of pesticides used in agriculture is in line with guidelines for good agricultural practices (**SAS**) **BD**: Prevention and remediation of soil contamination and clean-up historical contamination by 2036 (**SS**) **MD**: Regulates use of waste and materials (including sewage sludge) as fertilizer or soil improving substances in order to reduce impact on the environment including soils (**NS**)												
Optimal soil structure	**A-RD**: No targets; only investment support for low pressure tyres and tyre air pressure system (**SAS**)												
Enhance soil biodiversity	**A-GM**: Crop diversification for a healthy soil. Farmers need to grow 2 or 3 different crop types depending on their cultivated area (**SAS**)												
Enhance soil nutrient retention/use efficiency	**ND**: Threshold values for residual nitrate at the field parcel level between 1/10 and 15/11 as indicator for the nitrate leaching risk in winter; threshold values are depending on crop type, soil texture and water quality area (60-90 kg nitrate-N/ha from 0-90 cm) (**SAS**) **ND**: To steer P availability in the soil towards a target zone for soil fertility and limited environmental risks (**SAS**)	Weighted average residual nitrate (kg nitrate-N/ha in the 0-90 cm layer): 2004: 111 kg nitrate-N/ha – 2018: 89 kg nitrate-N/ha >70% of agricultural field parcels has available P content above the target of 18 mg P/100 g air dry soil in 2019 (note: this does not include parcels without analysis))											
Enhance water storage capacity	**PN-E**: It is investigated how to make soils and soil use more climate proof with special attention to drought and excess of water (**SS**) **PN-A**: focus on increasing water holding capacity of soils (**SAS**)												

Soil challenge	Current policy target	Current status of policy targets (when Indicators are available)	How wide is the gap between current policy realisation and target? (likert scale)					Argumentation	Aspirational goal – are the current policy targets futureproof (2050)? (likert scale)				Argumentation
			1	2	3	4	5		1	2	3	4	
			Very large	*Large*	*Halfway*	*Small*	*No gap*		*Future proof*	*Almost*	*Far*	*Very far*	
Land degradation in general	**SDG30:** Land degradation neutrality by 2030 in Flanders (net no extra degraded land) (**SS**) **V50**: ; land degradation is stopped by 2050	Indicators used: soil sealing 16% in 2016, polluted sites, soil erosion											

Step 3: How to achieve the aspirational goals

What: After setting the aspirational goals, the question remains **how to achieve this goal?** Or in other words, which soil management practices are most appropriate to achieve the aspirational goal. In this step, you are asked to address the question:

> (Q3) What soil related farm management practices are most promising to achieve the aspirational goals?

How: To answer the question, the same table as table 4 in Annex I is displayed, but empty. The aim is to select soil management practices that are most useable to achieve the aspirational goal for each soil challenge, in your opinion, regardless of the management practices that have been extracted from current policy documents.

Select three priority management practices for each soil challenge by putting '**X**' in the cells. So, each column should have three cells marked with '**X**' (table 6). When the management practice is not listed in the table yet, you can include this in de cell 'other'.

Additional there is an open question for every soil challenge (which is filled in table 7):

> (Q4) Is there **another instrument** that should be considered to achieve the aspirational goal?

These instruments can be very broad and can also include *for example* the stimulation of market-based and grassroots initiatives or informational campaigns. This is an open question you can think out-of-the box here.

Table 6 and 7 are provided on the next pages.

STEP 3 - Table 6: *Ranking table of soil management practices to achieve aspirational goals – three priority management practices for each challenge, indicated by X (so three 'X' per column) (if other is selected, please specify what management practice you are thinking of)*

	Maintain/increase SOC	**Avoid N_2O/CH_4 emissions**	**Avoid peat degradation**	**Avoid soil erosion**	**Avoid soil sealing**	**Avoid salinisation**	**Avoid acidification**	**Avoid contamination**	**Optimal soil structure**	**Enhance soil biodiversity**	**Enhance nutrient retention/use efficiency**	**Enhance water storage capacity**	**Other environmental stakes**
Crops/rotations													
More cereals													
More legume crops													
More grassland													
Intercropping/multiple cropping													
Cover/catch crops													
Perennial crops													
Permanent grazing													
Rotational grazing													
Zero grazing													
Other													
Tillage and traffic													
No till													

	Maintain/increase SOC	Avoid N_2O/CH_4 emissions	Avoid peat degradation	Avoid soil erosion	Avoid soil sealing	Avoid salinisation	Avoid acidification	Avoid contamination	Optimal soil structure	Enhance soil biodiversity	Enhance nutrient retention/use efficiency	Enhance water storage capacity	Other environmental stakes
Non-inversion/reduced tillage													
Non-inversion/minimum tillage													
Non inversion tillage													
Deep ploughing													
Contour plouging													
Terrace farming													
Controlled traffic farming													
Other													
Organic matter/nutrient management													
Reduced/more precise mineral fertiliser application													
Appropriate compost application													

	Maintain/increase SOC	Avoid N_2O/CH_4 emissions	Avoid peat degradation	Avoid soil erosion	Avoid soil sealing	Avoid salinisation	Avoid acidification	Avoid contamination	Optimal soil structure	Enhance soil biodiversity	Enhance nutrient retention/use efficiency	Enhance water storage capacity	Other environmental stakes
Appropriate farmyard manure application													
Biochar application													
incorporation of crop residues													
Fertilisation plan/advice													
Better manure storage													
Manure treatment													
Valorisation of waste streams													
Enhanced weathering													
Other													
Crop protection													
Mechanical weeding													
Precision herbicide application													
Other													

	Maintain/increase SOC	Avoid N_2O/CH_4 emissions	Avoid peat degradation	Avoid soil erosion	Avoid soil sealing	Avoid salinisation	Avoid acidification	Avoid contamination	Optimal soil structure	Enhance soil biodiversity	Enhance nutrient retention/use efficiency	Enhance water storage capacity	Other environmental stakes
Water management													
Irrigation													
Subsurface drainage													
Increasing water tables													
Allow flooding													
Other													
Buffer strips/small landscape elements													
Grass buffer strips													
Other buffer strips													
Hedges													
Other													
Agricultural systems													
Organic farming													
Agro-ecological farming													

	Maintain/increase SOC	**Avoid N_2O/CH_4 emissions**	**Avoid peat degradation**	**Avoid soil erosion**	**Avoid soil sealing**	**Avoid salinisation**	**Avoid acidification**	**Avoid contamination**	**Optimal soil structure**	**Enhance soil biodiversity**	**Enhance nutrient retention/use efficiency**	**Enhance water storage capacity**	**Other environmental stakes**
Precision agriculture													
Agroforestry													
Conservation agriculture													
Other													

Remarks on table 6

[Optionally, if applicable, clarifications and comments related to the choices in table 6 or general remarks can be addressed in this box]

STEP 3 - Table 7: *Other instruments to achieve aspirational goals per soil challenge*

	Possible instruments to achieve aspirational goal (short explanation)
	Is there another instrument, beside soil management practices, that should be considered to achieve the aspirational goal? These instruments can be out-of-the-box and include market-based instruments
Maintain/increase SOC	
Avoiding N_2O, CH_4 emissions	
Avoid peat degradation	
Avoid soil erosion	
Avoid soil sealing	
Avoid salinisation	
Avoid acidification	
Avoid contamination	
Optimal soil structure	
Enhance soil biodiversity	
Enhance soil nutrient retention/use efficiency	

Enhance water storage capacity	

Remarks on table 7

[Optionally, if applicable, general remarks on table 7 can be addressed in this box]

Step 4: Policy prioritization

What: Prioritization of the soil challenges to identify the **key themes** in Flanders.

(Q5) What do you expect that will be the main soil challenges that are most relevant for Flanders in the upcoming decades?

How: For this exercise, you should attribute a total of 100 points between the various soil challenges.

STEP 4 - Table 8: *Policy prioritization*

		Policy prioritization (a total of 100 points should be attributed between the various soil challenges)
	Example	*Flanders*
Maintain/increase SOC	*30*	
Avoiding N_2O, CH_4 emissiosn	*10*	
Avoid peat degradation		
Avoid soil erosion	*10*	
Avoid soil sealing		
Avoid salinisation		
Avoid acidification		
Avoid contamination		
Optimal soil structure		
Enhance soil biodiversity		
Enhance soil nutrient retention/use efficiency	*20*	
Enhance water storage capacity	*30*	
Total sum:	***100***	**100**

Thank you for your valuable inputs!

Please return this completed questionnaire to the coordinator for this task, being Greet Ruysschaert.

Contact

Greet Ruysschaert
Instituut voor Landbouw-, Visserij- en Voedingsonderzoek
Plant
Burg. Van Gansberghelaan 109
9820 Merelbeke
T +32 9 272 26 98
greet.ruysschaert@ilvo.vlaanderen.be

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ILVO

Instituut voor Landbouw-, Visserij- en Voedingsonderzoek
Burg. Van Gansberghelaan 92
9820 Merelbeke - België

T +32 9 272 25 00
ilvo@ilvo.vlaanderen.be
www.ilvo.vlaanderen.be